

Project Title: **Facility Package for the OU 7-10 Glovebox Excavator Method Project**
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Revision Number: 0

SECTION 16000 - ELECTRICAL GENERAL PROVISIONS

PART 1 - GENERAL

SUMMARY:

The Subcontractor shall provide, install, terminate, and test all the systems as described in the specification and shown on the drawings to make complete and operational electrical systems.

Section Includes, but is not limited to:

1. Power distribution including transformers, feeders, panels, and safety switches.
2. Normal and emergency lighting including lighting controls.
3. Normal and standby power distribution including controls.
4. Fire Alarm System (FAS), telephone (TELE), and data systems.
5. Lightning protection, power system grounding, data, and communication system grounding.
6. Instrumentation and Control.

RELATED SECTIONS:

15800	Heating and Cooling System
15801	Air Distribution System

REFERENCES:

The following documents, including others referenced therein, form part of this section to the extent designated herein. Unless otherwise indicated, use the latest edition in effect as of the date of these specifications.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C-2	National Electrical Safety Code (NESC)
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CANADIAN STANDARDS ASSOCIATION (CSA)

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1 CODE OF FEDERAL REGULATIONS (CFR)

2
3 29 CFR 1910 Subpart S OSHA Electrical Safety

4
5 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

6
7 NFPA-70 National Electrical Code (NEC)
8 NFPA-101 Life Safety Code

9
10 FACTORY MUTUAL

11
12 NATIONAL RECOGNIZED TESTING LABORATORIES (NRTL)

13
14 NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

15
16 INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

17
18 UNDERWRITERS' LABORATORIES, INC. (UL)

19
20 UL 486A Wire Connectors and Soldering Lugs for Use with Copper
21 Conductors

22
23 SUBMITTALS:

24
25 See Section 01300, Submittals, other electrical sections and the Vendor Data Schedule for
26 submittal requirements.

27
28 QUALITY CONTROL:

29
30 Regulatory Requirements (Codes and Standards): Comply with the following codes and
31 standards, except as modified herein:

32
33 Underwriters Laboratories (UL): All materials, appliances, equipment or devices shall
34 conform to the applicable standards of Underwriters Laboratories, Inc. All material,
35 appliances, equipment or devices shall be listed and/or labeled by UL or other nationally
36 recognized testing laboratories such as the CSA.

37
38 Completed electrical system shall conform with applicable provisions of the Special
39 Conditions, the Technical Specification, and the subcontract drawings.

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PART 2 - PRODUCTS

GENERAL:

Furnish all labor, materials, equipment and appliances required to complete the installation of the complete electrical systems. All labor, materials, service, equipment, and workmanship shall conform to the applicable chapters of the National Electrical Code (NEC), the National Electrical Safety Code (NESC), Occupational Safety and Health Administration (OSHA), and the terms and conditions of the electrical utility. All modifications required by these codes, rules, regulations, and authorities shall be made by the Subcontractor without additional charge to the Contractor.

MANUFACTURERS:

Where multiple units of a product are required for the electrical work, provide identical products by the same manufacturer without variations except for sizes and similar variations as indicated.

MATERIALS:

Except as otherwise indicated, furnish new electrical products, free of defects and harmful deterioration at the time of installation. Provide each product complete with trim, accessories, finish, guards, safety devices and similar components specified or recognized as integral parts of the product, or required by governing regulations.

Unless otherwise indicated by the drawings or specifications or approved in writing, the materials and/or equipment furnished under these specifications shall be the standard products of manufacturers regularly engaged in the production of such equipment, and shall be the manufacturer's standard design.

ENVIRONMENTAL CONDITIONS:

Climatic and Geographic Site Conditions

Site Elevation	4,917 feet
Barometric Pressure	12.27 psia
Relative Humidity	90% max. at 30°F (−1.1°C) dry bulb 15% min. at 60°F (+15.5°C) dry bulb
Uniform Building Code	Seismic Zone 2B

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- 1 The Subcontractor shall test all devices in the presence of the Contractor's Representative.
- 2 Subcontractor shall coordinate testing with the Contractor and schedule testing a minimum of
- 3 2 weeks in advance of the test. The Subcontractor shall inform the Contractor in writing of
- 4 the scheduled test to allow the Contractor to designate the Contractor's Representative. This
- 5 operational testing is in addition to testing required in separate sections of this specification.
- 6
- 7 Contractor Inspection: Surveillance will be performed by the Contractor's Representative to
- 8 verify compliance of the work to the drawings and specifications.
- 9
- 10 END OF SECTION 16000

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1 SECTION 16109 - SWITCHES, RECEPTACLES AND WALL PLATES

2
3 PART 1 - GENERAL

4
5 SUMMARY:

6
7 Subcontractor shall provide and install switches and receptacles of sizes, ratings, materials
8 and types as shown on the drawings.

9
10 Section Includes, but is not limited to:

11
12 Installation of new devices as detailed on the drawings.

13
14 RELATED SECTIONS:

15
16 Section 16000 Electrical General Provisions
17 Section 16195 Electrical Identification

18
19 REFERENCES:

20
21 See the list of general references in Section 16000.

22
23 SUBMITTALS:

24
25 Submittals include, but are not limited to:

- 26
27 1. Receptacle test device and receptacle test procedure.
28 2. Receptacle test results.

29
30 See Section 01300, Submittals, other electrical sections for additional submittal requirements.

31
32 PART 2 - PRODUCTS

33
34 MATERIALS:

35
36 Switches: Provide low voltage switches for general lighting in the WES and RCS. The
37 switches shall be compatible with the lighting control contractors provided for control of
38 these lights. Occupancy sensors will utilize passive infrared technology and will fit in a
39 standard switch box. The sensors shall be suitable for the coverage area shown on the
40 drawings. The occupancy sensors shall be watt stopper WI-200.

41
42 Switches for direct control of lighting fixtures shall be specification grade, 20 ampere,
43 120/277 V.

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RECEPTACLES:

General-Duty Duplex: Provide specification grade, duplex general-duty, flush or surface mounted receptacles, 2-pole, 3-wire grounding, with green hexagonal equipment ground screw, ground terminals and poles internally connected to mounting yoke, 20 ampere, 125 V, with metal plaster ears, side wiring, NEMA Configuration 5-20R unless otherwise indicated on the drawings. Acceptable manufacturers and models include the following:

Hubble	Model 5342
Daniel Woodhead	Model 5352DW
Pass & Seymour	Model 5342

Ground Fault Circuit Interrupter (GFCI) Receptacle: Provide commercial grade, duplex general duty ground fault circuit interrupter receptacles, 2-pole 3-wire grounding, feed-through type, flush or surface mounted, capable of protecting connected downstream receptacles on single circuit, grounding type, UL rated Class A, Group 1, 20 ampere rating, 125 V, 60 Hz; equipped with 20 ampere plug configuration NEMA 5-20R. Acceptable manufacturers and models include the following:

Hubble	Model 5352A
Daniel Woodhead	Model 5352GF
Pass & Seymour	Model 2091

Wall Plates: Provide single switch and duplex outlet wall plates for wiring devices, with ganging and cutouts as indicated, provide with metal screws for securing plates to devices, screw heads finished to match plate finish, and with plates possessing the following additional construction features:

Material and Finish/Indoor Use: Cover plates shall be Ivory color unbreakable nylon.

Material and Finish/Outdoor Use: Receptacle covers installed outdoors shall be rain tight with a NEMA 3R rating. Receptacle covers shall maintain this rating even when equipment is plugged in. This shall be accomplished by using flip lids or similar. Cover shall close automatically when released. All components of receptacle cover shall be made of corrosion resistant materials.

PART 3 - EXECUTION

INSTALLATION:

Install receptacles, switches and wall plates where indicated on the drawings in accordance with recognized industry installation practices.

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1 Receptacles to be mounted 36 in. from floor unless shown otherwise on the drawings.
2 Occupancy sensors to be mounted 48 in. from floor unless shown otherwise on the drawings.
3 Coordinate with other work including electrical raceway and equipment installation work, as
4 necessary to interface installation of wiring and devices with other work.

5
6 Install receptacles and switches only in electrical boxes which are clean and free from
7 building materials and debris.

8
9 **LABELING:**

10
11 Label all covers and plates. Install labels per Section 16195--Electrical Identification.

12
13 **FIELD QUALITY CONTROL:**

14
15 **Subcontractor Supplied Inspection and Tests:** The Subcontractor or his agents shall perform
16 the following:

- 17
18 1. Visual inspection to determine that equipment installation conforms to NEC, these
19 specifications and the drawings.
20 2. Subsequent to hooking-up cables/wires and devices, energize circuitry and
21 demonstrate functioning in accordance with requirements.
22 3. Each receptacle shall be tested with a portable receptacle circuit tester to test for
23 polarity, grounds, and opens.

24
25 Subcontractor shall furnish a data sheet, listing room numbers or area and number of
26 receptacle tested and test results.

27
28 Circuit testers shall be approved by the Contractor's Representative prior to use.

29
30 **Contractor Inspection:** Surveillance will be performed by the Contractor's Representative to
31 verify compliance of the work to the drawings and specifications.

32
33 **END OF SECTION 16109**

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SECTION 16110 - ELECTRICAL RACEWAYS

PART 1 - GENERAL

SUMMARY:

The Subcontractor shall provide and install electrical raceways for lighting, power, instrumentation, controls, communications and data systems.

Section Includes, but is not limited to:

1. Provide and install electrical raceways of types, grades, and sizes specified on the drawings.
2. Provide complete assembly of raceway including, but not necessarily limited to, couplings, elbows, adapters, hold-down straps, and other components and accessories as needed for a complete system.
3. Coordinate as necessary to integrate installation of electrical raceways and components with other work.
4. Label all conduits.

RELATED SECTIONS:

16000	Electrical Sections
16195	Electrical Identification

REFERENCES:

The following documents, including others referenced therein, form part of this Section to the extent designated herein. See the list of general electrical references in Section 16000.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	Pipe Threads, General Purpose (Inch)
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METAL FRAMING MANUFACTURER ASSOCIATION (MFMA)

MFMA-1	Metal Framing Channel
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1 NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

2
3 RN-1 Polyvinyl Chloride (PVC) Externally Coated
4 Galvanized Rigid Steel Conduit and Intermediate Metal
5 Conduit
6 VE-1 Metallic Cable Tray Systems
7

8 SUBMITTALS:
9

10 Submittals include, but are not limited to:
11

12 Cable Tray System
13 Cable Tray Splice Resistance Test Report
14

15 See Section 01300 Submittals, other electrical sections and the Vendor Data Schedule for
16 additional submittal requirements.
17

18 PART 2 - PRODUCTS
19

20 MATERIALS:
21

22 CONDUIT:
23

24 Metal conduit: Rigid Galvanized Steel (RGS) conduit or Intermediate Metal Conduit (IMC)
25 shall be used for all conductors buried in earth, in masonry, in concrete, and in damp or wet
26 locations. All conduit shall be UL approved, ½ -in. Minimum unless shown otherwise on the
27 drawings.
28

29 EMT: Electrical Metallic Tubing (EMT) shall be installed in all areas except those stipulated
30 for RGS or IMC. EMT shall be UL approved, standard weight, electro-galvanized steel, ½ -
31 in. Minimum size. EMT shall not be used in exposed outdoor locations that are subject to wet
32 conditions.
33

34 Flexible Conduit: Flexible metal conduit shall be installed in dry locations unless shown
35 otherwise on the drawings. Liquid-tight, flexible conduit shall be installed in wet locations.
36 Liquid-tight flex shall be grounding-type with a PVC jacket.
37

38 Fittings: Conduit fittings for rigid conduit (RGS or IMC) shall be rust-resistant cast steel.
39 Conduit fittings for EMT shall be steel, rain-tight compression type.
40

41 Junction Boxes: All junction boxes shall be galvanized unless shown otherwise. Small
42 junction boxes (4-11/16 in. square and smaller) shall be stamped from one piece of sheet steel
43 or welded construction and shall be galvanized. Where required to be weatherproof, small

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junction boxes shall be die-cast aluminum rated for wet locations. Enclosures larger than 12" x 12" shall be supported at each corner.

Framing Channel for Conduit/Box Support: Where indicated on the drawings or as required by the NEC, bolted framing channel shall be used to support conduits and electrical boxes. Galvanized steel channel shall be used in all outdoor/exterior locations and epoxy painted channel in all interior locations. The minimum size bolt used for bolting framing channel together for a support structure shall be 3/8". The exposed ends of all framing channel shall have a protective cap installed. Sizes shall be as detailed on the drawings. All framing channels shall be made of channel, fittings, and hardware as defined in MFMA-1 and shall be minimum 14-guage steel.

Cable Trays: Cable tray system shall be made of prefabricated sections, fittings, and accessories as defined in the latest NEMA Standards Publication VE-1. Cable tray shall be made to manufacturing tolerances as specified by NEMA VE1-2-03 and VE1-2-04. The cable tray shall be UL classified as equipment grounding conductors. The cable tray system shall be manufactured by B-Line Systems Inc., GS Metals Corp., Mono-Systems Inc., or MPHusky.

Cable tray shall be capable of carrying the allowable cable load with a safety factor of 2.0 and in addition, will support a 200-lb concentrated load without failure.

Cable trays shall be aluminum. Tray type shall be ventilated trough, 12" wide.

Aluminum Cable Tray: section, fitting side walls, and rungs shall be extruded aluminum association alloy 6063. Fabricated parts shall be made from alloy 5052.

Trays shall have an overall nominal depth of 6, in.

Cable tray sections side rails shall be I Beam, C Rail, or Z Rail. All straight sections shall be supplied in standard lengths of 12 or 24 ft; widths shall be 6, 8, 12, 18, 24, 30, 36, or 42 in., or as shown on the drawings or bill of materials. All sections shall be matched and compatible to assembly.

Splice plates shall be the bolted type using either square neck or ribbed neck carriage bolts and serrated flange lock nuts. The resistance of fixed splice connections between an adjacent section of tray shall NOT exceed 0.00033 ohm.

A barrier shall be installed in the tray over it's entire length . The barrier shall be installed as shown on the drawings.

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PART 3 - EXECUTION

INSTALLATION:

Install and support conduit, tubing, and duct products as indicated on the drawings in accordance with manufacturer's written instructions, applicable requirements of NEC, and National Electrical Contractors Association's "Standard of Installation". Comply with recognized industry practices to ensure that products serve intended functions. Where mounting channel is used, all exposed ends shall be capped. All above grade, exposed conduit shall be anchored to mounting channels a minimum of 12 inches long. Provide flexible conduit for motor connections, and for other electrical equipment connections where subjected to movement or vibration.

Provide liquid-tight flexible conduit for connection of motors and for other electrical equipment where subject to movement or vibration, and also where subjected to one or more of the following conditions:

1. Exterior locations
2. Moist or humid atmospheres where condensation can be expected to accumulate.

Rigid conduit (RGS and IMC) joints shall be cut square, reamed smooth in accordance with the NEC requirements. Joints shall be threaded and drawn up wrench tight in accordance with ASME B1.20.1. Bends or offsets shall be made with standard conduit bending dies that will NOT injure or flatten the pipe.

Rigid conduit terminating at cabinets and boxes shall be rigidly secured with locknuts inside and outside.

Male threads on exterior runs of galvanized steel conduits shall be thoroughly coated with a conducting sealing media such as petroleum base products. No red lead shall be used on any conduit joint.

All conduit penetrations through building walls, fire walls, or floors shall be sealed around outside of conduits with sealant appropriate for wall material (i.e., grout for concrete walls, fire stop caulk for drywall, etc.). Conduit penetrating exterior walls shall be internally weather sealed. Conduits 2 in. or greater, passing through fire floors, shall have UL or FM approved internal fire seals.

Where GFE or Contractor supplied security systems (Card Readers and/or door alarms for example) are to be installed on or near door locations, the door frame can be used as a raceway for wiring of these devices unless the door frame is grouted solid.

Conduit Identification: Label conduits per Section 16195--Electrical Identification.

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1 Cable Tray Installation: Expansion splice plates shall be installed as required for thermal
2 expansion and contraction.

3
4 Cable tray shall be hung from the building structural steel. Exact details will be determined
5 when the building manufacturer is selected. Support cable tray in accordance with the tray
6 manufacturer's recommendations. Cable trays shall be routed as NOT to interfere with
7 HVAC ducting or piping using vertical or horizontal offsets bolted into the tray system. No
8 unbolted jogs or off sets shall be allowed.

9
10 Installations shall be provided complete with barrier strip, dropouts, fittings, conduit
11 adapters, hold down devices, grommets and blind ends.

12
13 FIELD QUALITY CONTROL TESTING:

14
15 Subcontractor Inspection and Testing: The Subcontractor or his agents shall perform visual
16 inspections to determine that equipment installation conforms to the NEC, these
17 specifications, and the drawings. The Subcontractor or his agents shall perform the cable tray
18 splice test.

19
20 Contractor Inspection: Surveillance will be performed by the Contractor's Representative to
21 verify compliance of the work with the drawings and specifications.

22
23 END OF SECTION 16110

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SECTION 16120 - CABLE, WIRE, CONNECTORS AND MISCELLANEOUS DEVICES

PART 1 - GENERAL

SUMMARY:

The Subcontractor shall furnish, install, and terminate all cables, conductors, and devices to make complete and operational systems for this project.

Section Includes, but is not limited to:

Provide and install cables, wires, and wiring connectors of sizes, ratings, materials and types as specified on the drawings.

RELATED SECTIONS:

See other related sections for specific cables, wire, labels, and testing requirements.

16000 Electrical General Provisions

16195 Electrical Identification

REFERENCES:

The following documents, including others referenced therein, form part of this specification to the extent designated. Unless otherwise indicated, use the latest edition in effect as of the date of this specification.

INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS INC. (IEEE)

IEEE 576 Recommended Practice for Installation, Termination, and Testing of Insulated Power Cables as Used in the Petroleum and Chemical Industry
IEEE 1202 Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies

NATIONAL ELECTRICAL CABLE ASSOCIATION (NECA)

Standard for Installation Practices

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 79 Electrical Standard for Industrial Machinery

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UNDERWRITERS LABORATORIES, INC. (UL)

UL 1277 Electrical Power and Control Tray Cables with Optional
Optical Fiber Members
UL 1581 Electrical Wires, Cables, and Flexible Cords

SUBMITTALS:

Submittals include, but are not limited to the following:

1. Megger test procedure and test results
2. Continuity test procedure and test results

See Section 01300, Submittals and the Vendor Data Schedule, for additional submittal requirements.

PART 2 - PRODUCTS

WIRING MATERIALS, 600 V:

Conductors shall be stranded for all sizes of wire and cable larger than 10 AWG.

Conductors shall be copper for all sizes.

Wire insulation shall be Type THHN/THWN or XHHW for all 600 V conductors unless otherwise noted.

Minimum size of power conductors shall be No. 12.

Wiring shall be color-coded as indicated in the table below:

Conductor Code Color			
Conductor	208/120 Volts*	480/277 Volts	240/120 Volts*
Phase A	Black	Yellow	Black
Phase B	Red	Orange	Red
Phase C	Blue	Brown	
Neutral	White	Gray	White
Ground	Green	Green	Green
DC +	Red**		
DC -	Black**		

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- 1 1. For new circuits installed in existing panels only, black may be used for any phase
- 2 conductor, white for neutral and green for ground.
- 3 2. DC conductors colors shall conform to the above table or to NFPA 79.
- 4

5 Use appropriate colors of plastic tape or sleeves to identify conductors larger than #10 AWG
6 NOT furnished with colored insulation. Yellow phase tape shall consist of two separate bands
7 at each application point to avoid confusion with white, gray, or orange after aging. All wire
8 markers and phase tape shall be covered by clear heat-shrink sleeving.

9
10 Wire #10 AWG and smaller shall be furnished with continuous colored insulation for all
11 power, neutral and ground conductors when multiple circuits are installed to identify the
12 phase connected to, neutral, or equipment ground wiring. Bare copper conductors shall only
13 be used for ground conductors as shown on the drawings.

14 15 CONNECTORS:

16
17 All connections shall be tightened to the manufacturer's published torque values. Where
18 manufacturer does not specify torque requirements, connections shall be torqued to values
19 specified in UL 486A.

20
21 Connectors shall only be used as specified by manufacturer.

22
23 Spring type pressure connectors, such as "Scotchlock," shall be used for splicing No. 8 AWG
24 and smaller.

25
26 Splitbolt and/or lug type connectors such as "Burndy" shall be used for splicing No. 6 AWG
27 and larger.

28
29 Scotch mastic pads and two layers of half wrapped electrical tape shall be installed over all
30 splitbolt connectors.

31
32 Crimp on spade or ring-tongue lug connectors shall be used for connection to terminal boards
33 such as "Stakon."

34
35 Wire/Device Identification: See Section 16195-Electrical Identification.

36 37 HEATING CONTACTOR:

38
39 Each radiant heaters will be controlled with a heating contactor. The contactor will be a 3
40 pole device rated for an infrared heater drawing 30 Amperes at 480 Volts AC. The contactor
41 will be provided with a 120 V coil and a 480 V-120 V control power transformer. The
42 contactor will be electronically held. The contactor and Transformer shall be housed in a
43 NEMA 1 enclosure and shall have two indicating lights on the front of the enclosure. A green

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1 light shall indicate power to the contactor and a red light indicating that the contactor is
2 closed. Cutler Hammer ECL03

3
4 **THERMOSTAT:**

5
6 Each radiant heater will be controlled by a thermostat. The thermostat will be used to operate
7 the heater contactor. Provide a 120 V single pole, single throw, close on temperature fall. The
8 range of the thermostat will be 40°F - 100°F.

9
10 **VARIABLE FREQUENCY DRIVE:**

11
12 The Variable Frequency Drive (VFD) used for controlling the main exhaust fan shall be
13 capable of controlling a 20 hp motor. The VFD shall contain the features indicated on the
14 drawings and elsewhere in these specifications. The VFD shall be manufactured by
15 Allen-Bradley, the Allen-Bradley part number is 20AD027F1AYNNCNN.

16
17 **PART 3 - EXECUTION**

18
19 **INSTALLATION:**

20
21 **General:** Install electrical cable, wire, and connectors as follows:

- 22
23 1. As specified on the drawings
24 2. As specified in manufacturer's written instructions
25 3. As specified in applicable requirements of NEC and NECA's "Standard of
26 Installation"
27 4. In accordance with recognized industry practices to ensure products serve their
28 intended functions.

29
30 Coordinate cable and wire installation work with electrical raceway and equipment
31 installation work as necessary for proper interface.

32
33 Bundle and form wires inside wireways, panel boards, control panels, junction boxes, etc. to
34 clear pinch points, hinges, screws and clamps associated with the enclosure cover.

35
36 Pull conductors at the same time if more than one is being installed in a raceway. Do NOT
37 exceed the conductor manufacturer's recommended pulling tension.

38
39 Use pulling compound or lubricant where necessary (compound must NOT cause the
40 conductor or insulation to deteriorate.)

41
42 Use pulling methods including fish tape, cable, or rope that cannot damage raceway. Any
43 conductors that require mechanical assistance in pulling shall be installed in accordance with

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1 IEEE 576. Pulling calculations shall be performed on all conductors sized 1/0 AWG and
2 larger. Cable pull sheets shall be submitted for review prior to pulling.

3
4 Keep conductor splices to a minimum.

5
6 Install splices and taps that have a mechanical strength and insulation rating equivalent to, or
7 better than, the conductor.

8
9 Use splice and tap connectors that are compatible with conductor material.

10
11 Cables 250 KCMIL or greater entering panel boards or switchgear shall be supported by
12 cable ties or clamps to remove stress from breaker lugs.

13
14 FIELD QUALITY CONTROL:

15
16 Subcontractor Supplied Testing:

17
18 Meggering: Prior to terminating, test any power cable or wire 25 ft. or more in length for
19 insulation resistance using the megger (500 V megger for 300 V insulation and 1000 V
20 megger for 600 V insulation). Any wire identified with less than 10 megohms to ground or
21 other conductors shall be replaced before proceeding with the terminating process. List the
22 tested conductors on the required Test Data Submittal Sheet. An alternate megger test voltage
23 can be used as recommended by the manufacturer for the specific cable or wiring.

24
25 Electrical Continuity: Complete an electrical continuity test on all conductors, power and
26 control, as follows:

- 27
28 1. Before termination of conductors to terminals or devices
29 2. After the conductor connectors have been installed
30 3. After the conductors have been labeled

31
32 Use a battery-powered buzzer or calibrated ohmmeter to determine if all power, control,
33 grounding, and other conductors are properly installed and identified. List all conductors that
34 were tested on the required Test Data Submittal Sheets. The Subcontractor is required to
35 provide the Test Data Submittal Sheets.

36
37 Contractor Supplied Inspection and Testing: Wire and cables shall be checked for proper
38 termination and termination tightness. The Contractor's Representative shall witness torquing
39 of all connections unless indicated otherwise.

40
41 Surveillance will be performed by the Contractor's Representative to verify compliance of the
42 work to the drawings and specifications.

43 END OF SECTION 16120

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SECTION 16155 - MOTOR STARTERS (<600 VAC)

PART 1 - GENERAL

SUMMARY:

Subcontractor shall provide and install motor starters of types, grades, and sizes as specified on the drawings or in this specification. The Subcontractor is required to provide complete motor controller assemblies.

Subcontractor shall provide control, wiring, feeder, and installation of overload heaters. Subcontractor shall also provide and install wiring to the motor terminal box and connect the motor for the appropriate voltage and speed in accordance with the manufacturer's instructions. Subcontractor shall also verify that the motor rotation direction is correct.

Section Includes, but is not limited to:

1. Enclosure
2. Circuit breakers
3. Motor Circuit Protectors (MCP's), or fuses
4. Overload heaters
5. Control transformer if needed
6. Control switching
7. Additional components and accessories as needed for a complete motor controller system.

RELATED SECTIONS:

16000	Electrical General Provisions
16195	Electrical Identification

REFERENCES:

The following documents, including others referenced therein, form part of this Section to the extent designated herein:

NATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA 7.16.1.1

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1 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

2
3 NFPA-70 National Electrical Code (NEC)

4
5 SUBMITTALS:

6
7 Submittals include, but are not limited to the following:

- 8
9 1. Operation and Maintenance Manual
10 2. CC Test Report

11
12 Refer to Section 01300, Submittals and the Vendor Data Schedule, for additional submittal
13 requirements.

14
15 PART 2 - PRODUCTS

16
17 Underwriters' Laboratories (UL): All materials, appliances, equipment and devices shall
18 conform to the applicable standards of Underwriters Laboratories, Inc. All material,
19 appliances, equipment and devices shall be listed and/or labeled by UL.

20
21 MATERIALS:

22
23 Motor Starters: Provide motor starters and auxiliary components of types, sizes, ratings and
24 electrical characteristics indicated on the drawings that; (a) comply with manufacturer's
25 standard materials, design, and construction in the published product documentation; and (b)
26 as required for a complete installation.

27
28 General Motor Starter Requirements: Motor starters shall have a quick-make / quick-break
29 operating devise. Operating handles or buttons shall clearly indicate whether the unit is ON,
30 OFF, or TRIPPED. Starters shall be mounted in a metal enclosure having the appropriate size
31 and National Electrical Manufacturers Association (NEMA) rating as indicated on the
32 drawings. Added accessories, such as push buttons or pilot lights, shall not alter the NEMA
33 rating of the enclosure.

34
35 AC Fractional HP-Manual Starters: Provide manual single-phase fractional HP motor starters
36 of types, ratings, and electrical characteristics as specified on the drawings. Equip with
37 thermal overload relay and properly sized overload heater for protection at the rated voltage
38 and current.

39
40 Wiring: Wiring shall be NEMA Class II Type C. All control wiring shall be #16 AWG
41 minimum.

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ELECTRO-MECHANICAL MOTOR STARTERS:

Motor Starters Larger than 1 HP (Three Phase): Provide manual motor starters of types, ratings, and electrical characteristics as specified on the drawing.

Equip with solid state class 10 overload relay protection device that will detect and trip under any of the following conditions as a minimum:

1. Phase loss
2. Over-voltage
3. Under-voltage
4. Over-current conditions.

The overload relay shall have a manual reset button and the current overload adjustment shall be set according to the NEC requirements established in Article 430.

Combination Reversing and Nonreversing Starters: Provide full-voltage, alternating current, combination reversing or non-reversing starters of the NEMA size and voltage with the number of poles indicated on the drawings. The combination starters shall have a fusible disconnect switch, a MCP, or a circuit breaker of the amperage rating as indicated on the specific drawings or in this specification. MCP's and circuit breakers shall have a minimum rating of 20,000 amp (AIC) symmetrical interrupting capacity.

Provide dual element non-renewable fuses, sized for motor running protection, where fusible disconnect switches are used in place of circuit breakers or MCP's. If fuses are used, they shall have a voltage rating not less than the indicated circuit voltage. Fuses shall have the indicated current capacity and a minimum interrupting capacity of 100,000 amperes rms symmetrical. All fuses shall be Class R. Fuses used to protect motors shall be Bussman Type FRS-R or FRN-R. Fuses used to limit available short-circuit current shall be Bussman LPS-RK or LPN-RK.

Equip starters with a steel mounting plate, a molded arc hood, and a solid-state class-10 overload relay protection device that will detect and trip under any of the following conditions:

1. Phase loss
2. Over-voltage
3. Under-voltage
4. Over-current.

The device shall have a manual reset and the current overload adjustment shall be set according to the NEC requirements established in Article 430.

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1 Provide a mechanism for locking the operating handle in the OFF position.

2
3 If no other supply of 120 V control power is indicated, provide control transformer with a
4 [480] VAC fused primary and a 120 VAC fused and grounded secondary. Unless otherwise
5 indicated, provide control transformer with adequate VA capacity to operate connected pilot,
6 indicating, and control devices, plus 100% spare capacity.

7
8 When starters are specified with a remote source of control power, the main switch of the
9 motor circuit shall be supplied with a factory wired auxiliary N.O. contact. Contacts shall be
10 wired so that the incoming control power passes through the main switch auxiliary-contact
11 before it goes to the coil.

12
13 All Outdoor motor starters shall be NEMA 3R and indoor shall be NEMA 12R unless
14 otherwise noted on contract drawings.

15
16 The Subcontractor shall also mount a plastic nameplate (about 1 x 2-in.) on the starter door to
17 read as follows (Refer to Section 16195 – Electrical Identification):

18
19 CAUTION
20 External Control

21
22 Voltage Source: _____ Circuit: _____
23 (Panel) (Circuit No.) (Voltage)
24

25 Auxiliaries: Provide the following auxiliary, function/device for each unit as applicable or as
26 specified on contract drawings:

- 27
28 1. Provide starters with manual start/stop push buttons mounted on the face of the starter
29 enclosure.
30 2. Local/Auto selectors shall be provided with NC contact in Local Position to
31 communicate to DCS/PLC
32 3. Starter overload protection shall be equipped with an “a” auxiliary contact to indicate
33 to DCS/PLC that overload protection has occurred.
34 4. Provide starters with 2 N.O. and 2 N.C. auxiliary contacts.
35 5. Provide starters with Red Lensed “RUN” Pilot Light and Green Lensed “STOP” Pilot
36 Light.
37
38
39
40
41
42
43

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1 PART 3 - EXECUTION

2
3 INSTALLATION:

4
5 Install motor starters as listed below:

- 6
7 1. As indicated on the drawings
8 2. In accordance with the manufacturer's written instructions, the applicable
9 requirements of NEC, and the National Electrical Contractors Association's "Standard
10 of Installation"
11 3. Complying with recognized industry practices, ensuring that products serve intended
12 functions.

13
14 Install fuses in fusible disconnects, if used.

15
16 Install heater elements in overload relays. Install and terminate all wiring in starter enclosure.
17 Wiring shall be neatly bundled and supported.

18
19 LABELING:

20
21 All motor starters shall be labeled. See Section 16195 for Electrical Identification.

22
23 FIELD QUALITY CONTROL:

24
25 Subcontractor Testing: Tests shall be performed by a NETA certified technician supplied by
26 the Subcontractor. Test per NETA 7.16.1.1. The test is to include but not limited to the
27 following:

- 28
29 1. Visual inspection to determine that equipment installation conforms to NEC, these
30 specifications, and the drawings.
31 2. Verify the fuses are sized as specified on the drawings.
32 3. Operate motor to verify correct phase rotation by verifying shaft rotates in the correct
33 direction

34
35 Contractor Inspection: Surveillance will be performed by the Contractor's Representative to
36 verify compliance of the work to the drawings and specifications.

37
38 END OF SECTION 16155

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SECTION 16160 - PANELBOARDS

PART 1 - GENERAL

SUMMARY:

Provide and install distribution and power panelboards of sizes, ratings, materials, and types as shown on the panel schedules. Panelboards shall be equipped with thermal-magnetic, molded case circuit breakers of trip ratings as shown on the panel schedules.

Section Includes, but is not limited to:

Furnish and install the panelboards shown on drawings and specifications including the following:

1. Enclosures
2. Bus bars
3. Breakers
4. Covers
5. Circuit directories
6. Wire labeling

Terminate all conductors inside enclosures.

RELATED SECTIONS:

16000	Electrical General Provisions
16195	Electrical Identification
16450	Grounding

REFERENCES:

The following documents, including others referenced therein, form part of this Section to the extent designated herein.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C57.12.01	General Requirements for Dry Type Distribution and Power Transformers
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NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA	Standard of Installation
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 1	Molded Case Circuit Breakers
NEMA ICS 2	Industrial Control Devices, Controllers and Assemblies
NEMA ICS	Terminal Blocks for Industrial Control Equipment and Systems
NEMA KS 1	Enclosed and Miscellaneous Distribution Equipment Switches (600 volts maximum)
NEMA PB 1	Panelboards
NEMA PB 1.1	Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	National Electrical Code (NEC)
---------	--------------------------------

SUBMITTALS:

Submittals include, but are not limited to:

1. Product Data
2. Panel Schedules

See Section 01300, Submittals and the Vendor Data Schedule for additional submittal requirements.

QUALITY CONTROL:

Regulatory Requirements (Codes and Standards): Comply with provisions of the following codes and standards unless otherwise specified herein.

NFPA 70
NECA Standard of Installation
NEMA 250
NEMA AB
NEMA ICS 2
NEMA ICS 4
NEMA KS 1
NEMA PB 1
NEMA PB 1.1

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1 PART 2 - PRODUCTS

2
3 MATERIALS:

4
5 Bussing Assembly and Temperature Rise: All bussing shall be copper. Panelboard bus
6 structure and main lugs or main breaker shall have current ratings as shown on the
7 panelboard schedule. Such ratings shall be established by heat rise tests with maximum hot
8 spot temperature on any connector or bus bar (NOT to exceed 50°C rise above ambient.)
9 Heat rise tests shall be conducted in accordance with UL Standard 67. The use of conductor
10 dimensions will NOT be accepted as a substitute or replacement of actual heat tests. All
11 panelboards must have ground and neutral bus installed.

12
13 Molded Case Circuit Breakers: Circuit breakers shall meet the requirements of Standard
14 NEMA AB 1 with integral thermal and instantaneous magnetic trip in each pole. Circuit
15 breakers shall be equipped with individually insulated, braced, and protected connectors. The
16 front faces of all circuit breakers shall be flush with each other. Large, permanent, individual
17 circuit numbers shall be affixed to each breaker in a uniform position. Tripped indication
18 shall be clearly shown by the breaker handle taking a position between "ON" and "OFF".
19 Provisions for adding more breakers must NOT require additional connectors.

20
21 Integrated Equipment Short Circuit Rating: Each panelboard, as a complete unit, shall have a
22 factory established short circuit current rating equal to, or greater than, the integrated
23 equipment rating shown on the panelboard schedule or on the drawings. This rating shall be
24 established by factory testing with the overcurrent devices mounted in the panelboard. The
25 short circuit tests on the overcurrent devices and on the panelboard structure shall be made
26 simultaneously by connecting the fault to each overcurrent device with the panelboard
27 connected to its rated voltage source. Method of testing shall be per UL Standard 67. The
28 source shall be capable of supplying the specified panelboard short circuit or greater. Factory
29 testing of panelboard overcurrent devices for short circuit rating only while individually
30 mounted is NOT acceptable. In addition, testing of the bus structure by applying a fixed fault
31 to the bus structure alone is NOT acceptable. Panelboards shall be factory marked with their
32 maximum short circuit current rating at the supply voltage and shall be UL listed.

33
34 Cabinet: Panelboard assembly shall be enclosed in a steel cabinet. The rigidity and gauge of
35 steel shall be as specified in UL Standard 50 for cabinets. The size of wiring gutters shall be
36 in accordance with UL Standard 67. Cabinets shall be equipped with latch and tumbler-type
37 lock on door of trim. Doors over 48" long shall be equipped with three-point latch and vault
38 lock. All locks shall be keyed alike. Endwalls shall be removable. Finish shall be gray-
39 backed enamel electrodeposited over clean phosphatized steel. A circuit directory frame and
40 card with a clear plastic covering shall be provided on the inside of the door.

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1 Safety Barriers: The panelboard interior assembly shall be dead front with the panelboard
2 front removed. Main lugs or main breakers shall have barriers on five sides. The barrier in
3 front of the main lugs shall be hinged to a fixed part of the interior. The end of the bus
4 structure opposite the mains shall have barriers.

5
6 Power Centers: Power centers consisting of a main primary circuit breaker, a 480 V – 208
7 Y/120 V Transformer, and a secondary main circuit breaker and a secondary distribution
8 center.

9
10 The transformer shall be insulated with a 185°C insulation system.

11
12 Required performance shall be obtained without exceeding the above indicated temperature
13 rise in a 40°C Maximum ambient with a 30°C average over 24 hours.

14
15 Cores to be constructed of high grade, M-6, grain-oriented, non-aging silicon steel with high
16 magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities
17 are to be kept well below the saturation point. The core laminations shall be clamped together
18 with structural steel angles.

19
20 The core of the transformer shall be visibly grounded to the enclosure by means of a flexible
21 grounding conductor sized in accordance with applicable NEMA, IEEE, and ANSI standards.

22
23 Circuit breakers and other components shall comply with other sections of this specification.

24
25 The design is based on a Cutler-Hammer P48G28T30P.

26
27 UL Listing: Panelboards shall be listed by Underwriters Laboratories and shall bear the UL
28 label. When required, panelboards shall be suitable, and marked in orange letters, for use as
29 service equipment.

30
31 PART 3 - EXECUTION

32
33 INSTALLATION:

34
35 Install panelboards as indicated on the drawings and in accordance with manufacturer's
36 written instructions, applicable requirements of NEC and National Electrical Contractors
37 Association's "Standard of Installation," and complying with recognized industry practices to
38 ensure that products serve intended functions.

39
40 Provide electrical connections within enclosures.

41
42 Provide filler plates for unused spaces in panelboards. Provide typed circuit directory for
43 each branch circuit, indicating the area and function served by each breaker. Revise directory

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1 to reflect circuiting changes required to balance phase loads. Provide engraved nameplates in
2 accordance with Section 16195.

3
4 Ground and bond panelboard enclosures according to the NEC and Section 16450.

5
6 FIELD QUALITY CONTROL:

7
8 Subcontractor Inspection and Testing: Visually inspect panelboards to ensure that equipment
9 installation conforms to NEC, these specifications, and the drawings. Measure steady state
10 load currents at each panelboard branch circuit; rearrange circuits in the panelboard to
11 balance the phase loads to within 20% of each other. Maintain proper phasing for multi-wire
12 branch circuits.

13
14 Contractor Inspection and Testing: Surveillance will be performed by the Contractor's
15 Representative to verify compliance of the work to the drawings and specifications.

16
17 CLEANING:

18
19 All panelboards, especially those with knockouts removed or holes sawed in the enclosure,
20 shall be thoroughly cleaned and vacuumed to ensure all metal scraps and shreds are removed
21 before the cover is installed.

22
23 END OF SECTION 16160

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SECTION 16195 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

SUMMARY:

The Subcontractor shall provide and install labels and identification as specified in this document and on the associated drawings. See electrical drawings for equipment identifiers.

Section Includes, but is not limited to:

Install labels on electrical and related equipment, including the following:

1. Wires
2. Cables
3. J-Boxes
4. Switches
5. Receptacles
6. Panels
7. Disconnects

RELATED SECTIONS:

16000 Electrical Sections

REFERENCES:

The following documents, including others referenced therein, form part of this section to the extent designated herein. See the list of general electrical references in Section 16000.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A13.1 Scheme for the Identification of Piping Systems

SUBMITTALS:

None required for this section.

QUALITY CONTROL:

Regulatory Requirements (Codes and Standards): Comply with provisions of the following codes and standards unless otherwise specified herein.

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1 ANSI Standard A13.1 with regard to type and size of lettering for raceway and cable labels.
2 NFPA 70

3
4 PART 2 - PRODUCTS

5
6 MATERIALS:

7
8 Adhesive Marking Labels for Raceway and Metal-Clad Cable: Pre-printed, flexible,
9 self-adhesive labels with legend, identifying system type, or voltage and phase.

10
11 Wire and Cable Designation Tape Markers: Self-adhering, oil and moisture resistant, vinyl
12 labels covered with clear heat shrink tubing. Letters shall be typed in black, non-smear ink.
13 Hand lettered labels shall not be used. Engraved identification tags may also be used.

14
15 Brass, Steel, or Aluminum Tags: Metal tags with stamped legend and punched holes for
16 fastener. Dimensions: minimum 2" x 2" x 19 gauge with 1/4-in. radius corners and 3/16-in.
17 hole for fastener.

18
19 Brass and Steel Labels: Black engraving and 3/16-in. holes punched in corners. Dimensions:
20 0.31 to 0.50 inches thick with 1/4-in. radius corners.

21
22 Engraved, Plastic-Laminated Labels, Tags, Signs, and Instruction Plates: Engraving stock
23 melamine plastic laminate, 1/16-in. minimum thick for signs up to 20 sq. in., or 8 inches in
24 length; 1/8-in. thick for larger sizes. Engraved legend and punched for mechanical fasteners.

25
26 Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, non-fading,
27 pre-printed cellulose acetate, butyrate signs with 20 gauge, galvanized steel backing, with
28 colors, legend, and size appropriate to the location. Provide 1/4-in. grommets in corners for
29 mounting.

30
31 Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or
32 number 6/32 galvanized steel machine screws with nuts, flat washers, and lock washers.
33 Signs and labels shall be glued in place using clean GE Silicone II adhesive. Duplex
34 receptacles and light switches shall be glued on only. Labels larger than 1" high x 2" long
35 shall be glued and screwed on.

36
37 LABEL MAKEUP, CONTENT, SIZE, AND LETTERING:

38
39 LABELS FOR ELECTRICAL EQUIPMENT:

40
41 General: Labels are to be made from materials that are compatible with the application. Brass
42 or stainless steel shall be used when indicated on the drawings.
43

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Equipment Label Content: Include the following, as applicable, on electrical power-distribution equipment labels:

1. Properly assigned identifier (as shown on drawings)
2. Noun name or function description
3. Equipment inventory number
4. Voltage and the number of phases
5. Power source (fed from) equipment identifier
6. Circuit number (if applicable)
7. Building in which power source is located (if different from equipment location.)
8. Transformer and disconnect switch labels shall contain the destination (fed to) power equipment identifier fed by the transformer secondary or disconnect switch.

Example Panel Labels:

S-LP-WL-3901
LIGHTING PANEL, 408/277V, 3 PHASE
FED FROM: PANEL EP-2, CKT 2, WMF-603
N-PP-WL-3901
POWER PANEL, 480/277V, 3 PHASE
FED FROM: TRANSFORMER N-XFR-3901

Example Transformer Label:

N-XFR-WL-3901
TRANSFORMER
ED FROM: SECTIONALIZER ST-2
FEEDS: PANEL N-PP-3901

Example Disconnect Label:

N-DS-WL-3901
DISCONNECT SWITCH
FED FROM: PANEL N-PP-3901, CKT 4
FEEDS: HEATER HV-EHTR-3903

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Equipment Label Colors: Background and legend colors for electrical equipment labels shall be as specified in Table I below.

Table I. Electrical Equipment Label Colors

Power System Classification	Power System Designator	Background Color	Legend Color
Normal	N	black	white
Standby	S	yellow	black
Emergency	E	white	red
UPS	U	white	red
Regulated	R	same as source	same as source
Direct current	DC	black	white

Equipment Label and Lettering Size: Electrical equipment label and lettering size shall be as specified in Table II. If equipment size constraints make the specified label size impractical, the label and lettering size will be as large as possible for that particular equipment application.

Table II. Electrical Equipment Label Sizes

Power Equipment Classification	Label Height (minimum)	Lettering Height First Line	Lettering Height Subsequent Lines
Primary Distribution Equipment	2½ inch	¾ inch	? inch
Secondary Power Distribution Switches	1 inch	? inch	¼ inch
Disconnect Switches	1 inch	? inch	¼ inch
Power Distribution Panels	1 inch	½ inch	¼ inch
Power Distribution Transformers	2 inch	½ inch	¼ inch
PCC/MCC Switchgear	2 inch	¾ inch	? inch
Switchboards			
Power Receptacles	? inch	3/16 inch	N/A

Labels for Light Switches and Receptacles: Labels shall be engraved plastic laminate. Labeling and lettering sizes shall be as specified in Table II above. Labeling shall be consistent with subcontract documents..

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1 Example Light Switch and Single Phase Receptacle Label: N-LP-3901 CKT 2, 120V

2
3 Three Phase Receptacles: Three phase power/welding receptacle labels shall include
4 identifier, voltage, source power panel, and circuit number.

5
6 Example Three Phase Receptacle Label:

7
8 N-RCP-3901, 480V

9 FED FROM: N-PP-3901, CKT 4

10
11 Identification and Labels for Circuits, Cables, and Wire: The method of identification shall
12 be as follows:

13
14 Panelboard Breakers: Label single-pole breakers with the single-pole space numbers. Label
15 double pole breakers with the first number of the two single spaces they occupy. Label three
16 pole breakers with the first number of the three single spaces they occupy.

17
18 For example, a three-pole breaker in spaces 1, 3, and 5 shall be labeled breaker No. 1. A two-
19 pole breaker in spaces 7 and 9 shall be labeled No. 7. A single pole breaker in space 11 shall
20 be labeled No. 11. Install a type written circuit directory in each panel and furnish a copy to
21 the Contractor.

22
23 Conductors: Conductor identification shall include the following:

- 24
25 1. Panel identifier
26 2. Circuit identification number from the panel with the destination equipment identifier
27 3. Voltage.

28
29 Example Conductor Label: A conductor from S-PP-2301, circuit No. 4, to S-DS-3901 would
30 be identified with the identification number S-PP-2301-4/S-DS-3901, 120V.

31
32 Below Grade Power Circuit Identification: Fasten identifying tags securely to cables, feeders,
33 power circuits in vaults, pull boxes, and junction boxes. Tags shall have engraved legend
34 corresponding with designations in specifications and drawings. Attach tags with
35 approximately 55-lb test monofilament line or one-piece self-locking nylon cable ties. Tag
36 cables at each entry and exit of the manhole or once in a pull box or J-Box.

37
38 Conductor Color Coding: Provide color coding for secondary service, feeder, and branch
39 circuit conductors throughout the project's secondary electrical system as specified in Section
40 16120.

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CONDUIT LABELS:

General: Identify conduit with a label attached parallel to or encircling the conduit. The label shall show a legend of the conductor characteristics, including the following:

1. Highest voltage level contained within the conduit
2. AC or DC current
3. Number of phases
4. Service type (FA for Fire Alarm, ENS for Emergency Notification, VP for Voice Paging, EVAC for Evacuation), if applicable.

Example Conduit Label: 120V, AC, 1 Ph, FA.

Label Color: Conduit labels shall be color-coded as specified in Table III below:

Table III: Conduit Label Colors

Power Type	Background Color	Lettering Color
Normal Power	Orange	Black
Standby Power	Yellow	Black
Emergency Power	White	Red

Labeling Size and Placement: The minimum letter height for content and identification labels of raceways and conduit shall be as specified in Table IV below. A letter size of at least one half the trade diameter is recommended for conduit. The label shall be as long as required to display the specified information.

Table IV. Conduit Label Sizes

Raceway or Conduit Size (inches)	Minimum Height of Lettering (inches)
½ to 1¼	½
1½ to 2	¾
2½ to 6	1¼
8 to 10	2½
Over 10	3½

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Note: Size refers to the nominal diameter for conduit or the width of the raceway or cable tray.

High Voltage Feeders: Identify high-voltage (over 600 V) feeder conduit by the words "DANGER-HIGH VOLTAGE" in black letters 2-in. high, stenciled at 10-ft intervals over a continuous painted orange background.

PART 3 – EXECUTION:

INSTALLATION:

General: Install Equipment/System Circuit/Device Identification as follows:

General: Install Equipment/System Circuit/Device Identification as follows:

Apply equipment identification labels of engraved plastic-laminate on electrical equipment, including the central or master unit of each electrical system and each sub breaker or controller. This includes medium and low-voltage power distribution/communication/signal/alarm systems. Match the text to terminology and numbering of the subcontract documents and shop drawings. Apply labels for each unit of the categories of electrical work listed below:

1. Panelboards, electrical cabinets, and enclosures
2. Access doors and panels for concealed electrical items
3. Motor starters and Motor Control Center (MCC) main cabinets
4. Power transfer equipment
5. Contractors
6. Control devices
7. Components, wires and cables
8. Disconnect and safety switches
9. Transformers
10. Fire alarm control panel
11. Receptacles
12. Light switches
13. Light fixtures
14. Power Control Centers (PCC) and each sub breaker.

Apply circuit/control/item designation labels of engraved plastic laminate for items listed below:

1. Disconnect switches
2. Breakers
3. Motor controllers

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4. Motor control centers
5. Substation and load centers
6. Similar items for power distribution and control components listed above.

For panelboards, provide and install a framed and typed circuit schedule (directory) with explicit description and identification of items controlled by each individual breaker. Furnish a copy of the panel directory to the Contractor.

Install labels at indicated locations as well as convenient viewing locations, free of obstructions and interference from operations and maintenance equipment.

Sequence of Work: If identification is to be applied to surfaces that require a finish, then install identification after the finish work is completed.

Identification and Labeling of Electrical Equipment: Attach equipment label(s) on the front of electrical equipment in as visible a location as possible. Use separate labels to identify cautions or dangers required by code and as designated on the drawings.

Labeling of Light Switches and Receptacles: Light switches and single-phase receptacles shall be labeled to identify the source power panel, circuit number, and voltage. Attach labels securely on or at each receptacle. Use construction adhesive GE Silicone II to glue labels to the cover.

Identification and Labeling of Fire Alarm and Supervisory Equipment: Label fire alarm and supervisory equipment per Specification 16721--Fire Alarm and Supervisory System.

Identification and Labeling of Circuits, Cables, and Wire: Each individual circuit breaker in a panelboard shall be clearly identified by a circuit number appropriate to the individual panelboard. Identify circuits, breakers, or spaces that are spare, blank, or utilized for power distribution on the panel legend provided by the Subcontractor or manufacturer.

Conductors to 120V light switches and 120V duplex receptacles do NOT need to be labeled.

Label individual switchgear cubicles/cells.

Each conductor or cable shall be clearly identified and labeled in electrical pull boxes or junction boxes. Engraved, laminated plastic identification tags are acceptable for this purpose when attached to each conductor.

Label exposed cables used for power distribution or instrumentation with the assigned identification number no less than every 100-ft for the total length of the cable. Individual conductors used for overhead power distribution shall be labeled at each termination point.

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If field applied conductor color-coding is used, apply colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6-in. from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-in. wide tape in colors as specified. Apply yellow phase tape consisting of two separate bands at each application point to avoid confusion with white, gray, or orange after aging. Do NOT obliterate or obstruct any cable identification markings when taping. Adjust tape locations slightly to prevent such visual obstructions. All wire markers and phase tape shall be covered by clear heat shrink sleeving.

Conduit Labeling: Exposed raceways and conduits shall be labeled within 3-ft of the power source and adjacent to process equipment; adjacent to each side of any penetration through floors, walls, or bulkheads. Place labels at intervals NOT to exceed 20-ft on straight runs of conduit.

Raceways and conduit shall be labeled at least once in each room through which they pass. For ease of identification, apply labels in a convenient and obvious location. Conduction ceiling space above suspended ceilings shall be labeled.

Warning, Caution and Instruction Signs: Install warning, caution, and instruction signs as follows:

1. Where required by NEC
2. As indicated on the drawings
3. Where required to assure safe operations and maintenance of electrical systems and of the items to which they connect
4. Engraved plastic-laminated instruction signs displaying instructions, explanations, cautions, dangers, or warnings personnel may need for the safe operation of the specific system or equipment being operated
5. Butyrate signs with metal backing for outdoor locations.

Identify Junction and Connection Boxes: Code-required caution sign for boxes shall be pressure-sensitive, self-adhesive label indicating system voltage in black, pre-printed on orange background. Attach labels on the outside of the box cover. Mount an engraved plastic laminate label, identifying the circuits contained in the box, to the box cover. For exposed locations, use pressure-sensitive plastic labels. Use similar labels and tags for concealed boxes.

FIELD QUALITY CONTROL:

Contractor Inspection: Surveillance will be performed by the Contractor's Representative to verify compliance of the work to the drawings and specifications.

END OF SECTION 16195

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SECTION 16360 - DISCONNECT SWITCHES 600 V AND LESS

PART 1 - GENERAL

SUMMARY:

Section Includes, but is not limited to:

The Subcontractor shall provide and install electrical disconnect switches of types, grades, and sizes as shown on the drawings. Provide complete assembly including, but not necessarily limited to hubs, fuses, and other components and accessories as needed for a complete system.

RELATED SECTIONS:

16110	Electrical Raceways
16195	Electrical Identification

REFERENCES:

The following documents including others referenced therein, form part of this Section to the extent designated herein:

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

NEMA ICS 2,	Part 8 Disconnect Devices for Use in Industrial Control Equipment
NEMA 250	Enclosures for Electrical Equipment
5-WD	Fuses

NATIONAL FIRE PROTECTION ASSOCIATION

NFPA 70	National Electrical Code (NEC)
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SUBMITTALS:

Catalog Data

See Section 01300, Submittals and the Vendor Data Schedule for submittal requirements.

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1 PART 2 - PRODUCTS

2
3 MANUFACTURERS:

4
5 Acceptable Manufacturers: Square D, General Electric, Cutler-Hammer or Westinghouse.

6 MATERIALS:

7
8 Disconnects: Disconnect switches shall be UL listed, NEMA type, heavy duty, single throw,
9 fused, and have current and voltage rating as shown on the drawings.

10
11 Switches shall be operated with external operating handle which is an integral part of the
12 box--not the cover. The operating mechanism shall be quick-make, quick-break and shall not
13 be capable of being restrained by the operating handle during the opening and closing
14 operation.

15
16 Dual interlocks shall interlock the switch box cover with the switch mechanism and shall
17 prevent opening or closing the box cover when the switch contacts are closed and the switch
18 mechanism is in the "ON" position. An interlock release shall be provided to defeat the
19 interlocking mechanism and to permit opening the box cover when the switch contacts are
20 closed. To defeat the interlock release and permit opening the box cover shall require an
21 external hand tool.

22
23 Switch handles shall be designed for padlocking in the "OFF" position, locking the door
24 closed to inhibit access to the switch. All current-carrying metal parts of the switch shall be
25 enclosed.

26
27 Provide dual element non-renewable fuses, sized for motor running protection, heater
28 protection or as shown on the drawings. All fuses shall be class R.

29
30 PART 3 - EXECUTION

31
32 INSTALLATION:

33
34 Install disconnect switches as indicated on the drawings and in accordance with
35 manufacturer's written instructions, applicable requirements of NEC and National Electrical
36 Contractors Association's "Standard of Installation," and comply with recognized industry
37 practices to ensure that products serve intended functions.

38
39 Install disconnecting devices associated with motors within sight of the motor driven device
40 where practical. In all cases the disconnecting device shall be clearly labeled to distinguish
41 which motor/piece of equipment it disconnects.

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1 **LABELING:**

2
3 For labeling requirements see Section 16195 -- Electrical Identification.

4
5 **FIELD QUALITY CONTROL:**

6
7 **Site Tests:** Visual inspection to determine that equipment installation conforms to NEC, these
8 specifications and the drawings.

9
10 **Contractor Inspection:** Surveillance will be performed by the Contractor's Representative to
11 verify compliance of the work to the drawings and specifications.

12
13 **END OF SECTION 16360**

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SECTION 16450 - GROUNDING

PART 1 - GENERAL

SUMMARY:

Section Includes, but is not limited to:

Subcontractor shall provide and install grounding of sizes, ratings, materials and types as shown on the drawings and as recommended by the NEC and the NESC.

Section Does Not Include: For grounding requirements for the following systems, see the Section listed:

COMMUNICATION SYSTEMS:

16610	Telephone System
16721	Fire Alarm and Supervisory (FA) System

LIGHTNING PROTECTION SYSTEMS:

16650	Lightning Protection
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RELATED SECTIONS:

05100	Structural Steel and Miscellaneous Metals
16000	Electrical Sections

REFERENCES:

The following documents, including others referenced therein, form part of this Section to the extent designated herein. Unless otherwise indicated use the latest edition in effect as of the date of these specifications.

AMERICAN NATIONAL STANDARDS ASSOCIATION (ANSI)

ANSI C2	National Electrical Safety Code (NESC)
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NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	National Electrical Code (NEC)
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1 SUBMITTALS:

2
3 Test Procedure
4 Test Report
5

6 Refer to section 01300, submittals and the Vendor Data Schedule for additional submittal
7 requirements.
8

9 PART 2 - PRODUCTS

10
11 MATERIALS:

12
13 Equipment grounding conductors shall be green insulated or bare copper, sized and located as
14 shown on the drawings. Use field-applied, green tape for insulated conductors in accordance
15 with Section 16195 – Electrical Identification.
16

17 rounding grid connections below grade shall be made by the exothermic welding process or
18 listed nonreversible compression fittings.
19

20 Exothermic welds shall be Cadweld.
21

22 Nonreversible compression fittings shall be Burndy HyGround.
23

24 Ground bus bar shall be 1/4" thick x 4" W x 24" L with mounting insulators and brackets.
25 VFC, Inc., GBI Series.
26

27 PART 3 - EXECUTION

28
29 INSTALLATION:

30
31 Install a complete grounding system as indicated on the drawings in accordance with
32 applicable requirements of the NEC, the NESC, and complying with recognized industry
33 practices to ensure that products serve intended functions and comply with requirements.
34

35 All exposed noncurrent-carrying metallic parts of electrical equipment, raceway systems,
36 cable trays, air ducts, building steel, and the neutral conductor of the wiring system shall be
37 grounded. The riser of all firewater systems and all in-building, non-firewater, metallic
38 piping shall be grounded.
39

40 In addition to the equipment grounding conductor routed with the branch circuit, the metal
41 frame of large equipment (i.e., firewater risers, fuel tanks, electric fire pump controller and
42 motor, etc.) shall be grounded via a No. 2 stranded, bare copper grounding conductor to a

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grounding bus bar (separate from the service panel grounding bus). The grounding bus bar shall be bonded to the building grounding grid as shown on the drawings.

All in-building metallic water piping, all metallic air ducts, all building structural steel (in particular building corner columns), rebar, and underground metallic conduit and grounding cables shall be connected to the building grounding grid. These connections to the grounding grid shall be exothermically welded or by utilizing nonreversible compression fittings. Beam or compression type grounding clamps shall be used for all above grade grounding attachments to building steel. Exothermic welds to structural steel shall not be allowed.

All conduit (except spares) shall contain a dedicated grounding conductor.

Conduit shall not be used as the grounding conductor.

Nonreversible Compression Connections: Connections shall be made in accordance with manufacturer's written recommendation.

Exothermic Welds: Exothermic welds shall be made in accordance with the manufacturer's written recommendations.

FIELD QUALITY CONTROL:

Site Tests: The Subcontractor or his agents shall perform visual inspections to determine that the grounding installation conforms to the NEC, these specifications, and the drawings.

Testing: Perform the following field quality-control testing:

After installing grounding system but before permanent electrical circuitry has been energized. Perform a ground resistance test.

Contractor Inspection: Surveillance will be performed by the Contractor's Representative to verify compliance of the work to the drawings and specifications.

END OF SECTION 16450

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SECTION 16460 - TRANSFORMERS, GENERAL LIGHTING AND DISTRIBUTION DRY TYPE, INDOOR AND OUTDOOR, UNDER 600 VOLTS

PART 1 - GENERAL

SUMMARY:

Section Includes, but is not limited to:

1. The Subcontractor shall provide and install transformers of sizes, ratings, and types as shown on the drawings.
2. The Subcontractor shall install the transformers in the approximate locations shown and comply with all provisions of the NEC and NESC as to clearances, grounding, location, local disconnects, and NEMA ratings.

RELATED SECTIONS:

Section 16110	Electrical Raceways
Section 16195	Electrical Identification
Section 16450	Grounding

REFERENCES:

The following documents, including others referenced therein, form part of this Section to the extent designated herein.

Section 16000 References.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C57.12.01	General Requirements for Dry Type Distribution and Power Transformers
ANSI C57.12.28	Switchgear and Transformers – Pad – Mounted Equipment – Enclosure Integrity
ANSI C57.12.70	Terminal Markings and Connections for Distribution and Power Transformers
ANSI C57.12.80	Terminology for Power and Distribution Transformers
ANSI C57.12.91	Test Code for Dry-Type Distribution and Power Transformers

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IEEE C2 National Electric Safety Code (NESC)

NATIONAL ELECTRIC CONTRACTORS ASSOCIATION (NECA)

NECA ST20 Standard of Installation

NATIONAL ELECTRIC MANUFACTURER'S ASSOCIATION (NEMA)

NEMA 250 Enclosures for Electrical Equipment

NEMA ST 1 Specialty Transformers

NEMA ST 20 Dry-Type Transformers for General Applications

UNDERWRITERS' LABORATORIES, INC. (UL)

UL 486A Wire Connectors and Soldering Lugs for Use with
Copper Conductors
UL 506 Specialty Transformers

SUBMITTALS:

Product Data: Include data on features, components, ratings, and performance for each type of transformer specified. Include dimensioned plans, sections, and elevation views. Show minimum clearances and installed devices and features.

Product Certification: Signed by manufacturers of transformers certifying that the products furnished comply with requirements.

Refer to Section 01300, Submittals and the Vendor Data Schedule for additional requirements.

QUALITY CONTROL:

Regulatory Requirements, Codes and Standards: Comply with the provisions of the following codes and standards unless otherwise specified herein.

NFPA 70 National Electrical Code (NEC)

UL 1561 Dry-Type General Purpose and Power Transformers

Listing and Labeling: Provide transformers specified in this Section that are listed and labeled in accordance with the NEC definitions. Transformers shall be listed by UL for the rated temperature rise specified in Part 2.

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AND OUTDOOR, UNDER 600 VOLTS 16460 - 2 of 5

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1 DELIVERY, STORAGE AND HANDLING:

2
3 The transformers shall be prepared for shipment within the Continental United States. All
4 accessories shall be protected from damage. The transformers shall be sealed to prevent entry
5 of moisture of foreign materials during shipment. Documents as indicated shall be required.

6
7 Apply temporary heat according to manufacturer's written instructions within the enclosure
8 of each ventilated-type unit throughout periods during which equipment is not energized and
9 is not in a space that is continuously under normal control of temperature and humidity.

10
11 PART 2 - PRODUCTS

12
13 MATERIALS:

14
15 This specification covers the design, fabrication, installation, testing, and inspection of indoor
16 and outdoor, under 600 volts, general lighting and distribution, dry type transformers.

17
18 It is not the intent to set forth those performance requirements, which are adequately
19 specified in applicable standards.

20
21 All components shall function in a satisfactory manner within their rated capacity under the
22 specified service conditions regardless of whether all necessary specific performances are set
23 forth herein or in applicable standards.

24
25 TECHNICAL REQUIREMENTS:

26
27 Transformer Voltages: Transformers shall be 480 volt Delta primary and 208Y/120 volt Wye
28 secondary.

29
30 Taps: Transformers shall have a minimum of four 2 1/2 % full capacity primary taps, two
31 above and two below rated voltage. Exact voltages to be as designated on the drawings.

32
33 Insulation Class: Insulating materials to be in accordance with NEMA ST 20 Standard for a
34 220°C UL component recognized insulation system.

35
36 Rated Temperature Rise: Transformers shall be 150°C temperature rise above 40°C ambient.
37 The maximum temperature of the top of the enclosure shall not exceed 50°C rise above 40°C
38 ambient.

39
40 Windings: Transformer coils shall be of the continuous wound construction and shall be
41 impregnated with non-hygroscopic, thermosetting varnish.

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1 Cores: Cores to be constructed of high grade, M-6, grain-oriented, non-aging silicon steel
2 with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux
3 densities are to be kept well below the saturation point. The core laminations shall be
4 clamped together with structural steel angles.

5
6 Core and Coil Mounting: The completed core and coil shall be bolted to the base of the
7 enclosure but isolated there from by means of rubber, vibration-absorbing mounts. There
8 shall be no metal-to-metal contact between the core and coil and the enclosure. On
9 transformers 500 kVA and smaller, the vibration isolating system shall be designed to
10 provide a permanent fastening of the core and coil to the enclosure.

11
12 Core Grounding: The core of the transformer shall be visibly grounded to the enclosure by
13 means of a flexible grounding conductor sized in accordance with applicable NEMA, IEEE,
14 and ANSI standards.

15
16 Enclosures: Transformers shall be in a ventilated sheet steel enclosure of a heavy gauge as
17 described in the NEMA Standards. The ventilating openings shall be designed to prevent
18 accidental access to live parts in accordance with UL, NEMA, and NEC standards for
19 ventilated enclosures Transformers shall be designed so they can be either floor- or wall-
20 mounted. Above 75 kVA and 45 kVA transformers shall be floor-mounted design.

21
22 FINISHES:

23
24 Indoor Units: Manufacturer's standard paint over corrosion-resistant pretreatment and primer.

25
26 Outdoor Units: Comply with ANSI C57.12.28.

27
28 SOUND LEVELS:

29
30 Normal-Sound-Level Units: Meet NEMA ST 20 standard sound levels when factory tested
31 according to IEEE C57.12.91.

32
33 PART 3 - EXECUTION

34
35 INSTALLATION:

36
37 Install transformers as indicated on the drawings and in accordance with manufacturer's
38 written instructions, applicable requirements of NEC and National Electrical Contractors
39 Association's "Standard of Installation," and complying with recognized industry practices to
40 ensure that products serve intended functions.

41
42 Arrange equipment to provide adequate spacing for access and for circulation of cooling air.

TRANSFORMERS, GENERAL LIGHTING AND DISTRIBUTION DRY TYPE, INDOOR
AND OUTDOOR, UNDER 600 VOLTS 16460 - 4 of 5

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1 Tighten electrical connectors and terminals according to manufacturer's published torque-
2 tightening values. If manufacturer's torque values are not indicated, use those specified in UL
3 486A.

4
5 Labeling: For labeling requirements see Section 16195 - Electrical Identification.

6
7 GROUNDING:

8
9 Separately Derived Systems: Make grounding connections to grounding electrodes and
10 bonding connections as indicated and to comply with the NEC. Comply with Section 16450 -
11 Grounding.

12
13 FIELD QUALITY CONTROL:

14
15 Subcontractor Inspection: Visual inspection to determine that equipment installation
16 conforms to NEC, these specifications and the drawings.

17
18 Contractor Inspection: Surveillance will be performed by the Contractor's Representative to
19 verify compliance of the work to the drawings and specifications.

20
21 END OF SECTION 16460

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SECTION 16500 - LIGHTING

PART 1 - GENERAL

SUMMARY:

Section Includes, but is not limited to:

1. Provide, install, and terminate lighting fixtures of sizes, types, and ratings as shown on the drawings; comprised of, but not necessarily limited to, lamps, lampholders, reflectors, ballasts, starters, wiring, accessories, and anchor systems.
2. Provide and install the necessary equipment for supporting or coordinating the hanging of all light fixtures.
3. Provide and install lighting control panel including contractors, relays and switches as necessary to control the lighting fixtures as indicated on the drawings.

RELATED SECTIONS:

16120 Cable, Wire, and Connectors and Miscellaneous Devices

REFERENCES:

The following documents, including others referenced therein, form part of this Section to the extent designated herein:

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

NEMA C82.1	Electric Lamp Ballast – Line Frequency Fluorescent Lamp Ballast (ANSI)
NEMA C82.4	Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (ANSI)
NEMA C82.11	High-Frequency Fluorescent Lamp Ballast (ANSI)

NATIONAL FIRE PROTECTION ASSOCIATION

NFPA 70	National Electrical Code (NEC)
NFPA 101	Life Safety Code

UNDERWRITERS LABORATORIES

UL 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 924	Emergency Lighting and Power Equipment

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UL 1029 High-Intensity-Discharge Lamp Ballasts
UL 1598 Luminaries

SUBMITTALS:

Submittals include, but are not limited to:

Product Data: For each type of lighting fixture scheduled, arranged in order of fixture designation. Include in catalog data the features, accessories, and finishes for the following:

1. Physical description of fixture, including dimensions and verification of indicated parameters.
2. Emergency lighting unit battery and charger.
3. Fluorescent and high-intensity-discharge ballasts.
4. Lamps.

Wiring Diagrams: Power, signal, and control wiring.

Test Reports: Submit completed test reports in accordance with the Field Quality Control Section.

Warranty: See Section 01300 Submittals for additional warranty information.

1. Special Warranty for Emergency Lighting Unit Batteries
2. Special Warranty for Fluorescent Ballasts

Refer to Section 01300, Submittals and the Vendor Data Schedule for additional submittal requirements.

QUALITY CONTROL:

General: Electro-magnetic, discrete electronic, and integrated circuit (IC) electronic ballast design and construction shall conform to Certified Ballast Manufacturer (CBM) Standards.

Regulatory Requirements, Codes and Standards: Comply with the provisions of the following codes and standards unless otherwise specified herein.

1. CBM Standards
2. NFPA-70 NEC Articles pertaining to lighting and fixtures

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1 WARRANTY:

2
3 Special Warranty for Emergency Lighting Unit Batteries: Manufacturer's standard form in
4 which manufacturer of battery-powered emergency lighting unit agrees to repair or replace
5 components of rechargeable batteries that fail in materials and workmanship within specified
6 warranty period.

7
8 Warranty Period: 10 years from date of Substantial Completion. Full warranty shall apply for
9 first year, and prorated warranty for the remaining years.

10
11 Special Warranty for Fluorescent Ballasts: Manufacturer's standard form in which
12 manufacturer agrees to repair or replace ballasts that fail in materials and workmanship
13 within specified warranty period.

14
15 Warranty Period for Electronic Ballasts: 5 years from date of Substantial Completion.

16
17 Warranty Period for Electromagnetic Ballasts: 3 years from date of Substantial Completion.

18
19 PART 2 - PRODUCTS

20
21 MANUFACTURES:

22
23 Subject to compliance with requirements, provide products of one of the following:

24
25 Ballasts: Motorola, OSRAM Sylvania, Advance Mark V and Advance Mark VII (for
26 dimming).

27
28 FIXTURES AND COMPONENTS:

29
30 Provide and install all fixtures, lamps, and tubes of the types and wattages indicated on the
31 drawings.

32
33 Fluorescent Fixtures: Comply with UL 1598. Fluorescent fixtures shall be rapid start, bipin
34 type, with individually fused, high power factor Class P ballasts as indicated on the drawings.

35
36 Fluorescent Ballasts: Fluorescent ballasts shall be electro-magnetic, discrete electronic or
37 integrated circuit (IC) electronic as called for on the drawing lighting fixture schedule.

38
39 Electro-magnetic ballast: Electro-magnetic ballast shall be of high power factor, high
40 efficiency, Class P type. Ballast shall be rated for starting and operating at a minimum of
41 60°F (-20°F for cold weather) and be bonded with non-asphaltic thermo setting compound
42 compatible with any contained fluid. Ballast shall not contain polychlorinated biphenyls
43 (PCB's) and shall be maximum sound Level B.

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Discrete electronic ballast: Discrete electronic ballast (with no laminated electromagnetic components) shall have a minimum power factor of .95, UL Class P, rapid start, rated for starting and operating at a minimum of 60°F. Ballast total harmonic distortion shall be less than 20% according to NEMA C82.11. Lamps current crest factor shall not exceed 1.5, with a sound Level "A".

Integrated Circuit (IC) electronic ballast: IC electronic ballast shall have a minimum power factor of .98, UL Class P, rapid start, rated for starting and operating at a minimum of 60°F. Ballast total harmonic distortion shall be less than 10% according to NEMA C82.11. Lamp current crest factor shall not exceed 1.5, with a sound Level "A". Ballast shall have a frequency of operation of 20K Hz or greater, and operate without a visible flicker.

BALLAST SOUND LEVELS:

Sound Level A - 20 to 24 dB

Sound Level B - 25 to 30 dB

Fluorescent Lamps: Fluorescent fixtures shall be supplied with 32 watt high efficiency, low mercury, fluorescent lamps. The lamps shall be designed to pass the Environmental Protection Agency's Toxicity Characterization Leaching Procedure (TCLP) requirements at end of life. Fluorescent Lamps shall have a color temperature of 4100K in the Kelvin Range.

Metal Parts: Free of burrs and sharp corners and edges.

Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

Plastic Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation. The lens thickness shall be 0.125-inch minimum unless different thickness is scheduled. The lens shall be UV stabilized.

HID Fixtures: Comply with UL 1598.

High-Intensity Discharge Lamp Ballasts: Comply with NEMA C82.4 and UL 1029. Shall include the following features, unless otherwise indicated.

1. Type: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F for single-lamp ballasts.
3. Normal Ambient Operating Temperature: 104 deg F.

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1 Auxiliary, Instant-On, Quartz System: Automatically switches quartz lamp on when fixture is
2 initially energized and when momentary power outages occur. Automatically turns quartz
3 lamp off when HID lamp reaches approximately 60 percent of light output.

4
5 Exit Signs: Comply with UL 924. Exit signs shall be translucent green with opaque white
6 letters. Exit signs shall use LEDs for illumination. Letter size shall be in accordance with
7 NFPA 101.

8
9 Emergency Lighting Units: Comply with UL 924. Battery shall be sealed, maintenance-free,
10 lead-acid type with minimum 10-year nominal life and special warranty. Charger shall be
11 fully automatic, solid-state type with sealed transfer delay.

12
13 Lighting Control Panel: The lighting control panel shall be designed to switch the loads as
14 indicated on the drawings. The complete unit including relays, contactors and control shall be
15 supplied by a single manufacturer.

16
17 PART 3 - EXECUTION

18
19 INSTALLATION:

20
21 Install lighting fixtures of types indicated, where shown and at indicated heights; in
22 accordance with lighting fixture manufacturer's written instructions and with recognized
23 industry practices; to ensure that fixtures comply with requirements and serve intended
24 purposes.

25
26 Provide and install the necessary equipment for supporting or coordinating the hanging of all
27 light fixtures. Fasten fixtures securely to structural support members of building per UBC
28 Seismic Zone 2b requirements. Minimum horizontal seismic forces shall be 15% of fixture
29 weight for normal lighting and 23% of weight of fixture for emergency lighting. Check to
30 ensure that solid pendent fixtures are plumb.

31
32 All fixtures shall be wired from outlet boxes with minimum size No. 12 AWG, type THHN
33 wire for through wiring of fluorescent fixtures.

34
35 FIELD QUALITY CONTROL:

36
37 Subcontractor Supplied Inspection and Testing: The Subcontractor or his agents shall
38 perform the following tests:

- 39
40 1. Upon completion of installation of lighting fixtures, apply electrical energy to
41 demonstrate capability and compliance with requirements.
42 2. Replace bulbs or tubes that are noticeably dim, correct malfunctioning units at site,
43 then retest to demonstrate compliance; otherwise, remove and replace with new units,
44 and proceed with retesting.

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1 Contractor Inspection: Surveillance will be performed by the Contractor's Representative to
2 verify compliance of the work to the drawings and specifications.

3
4 ADJUSTING AND CLEANING:

5
6 Clean lighting fixtures of dirt and debris upon completion of installation.

7
8 Protect installed fixtures from dirt, debris, and damage during remainder of construction
9 period.

10
11 END OF SECTION 16500
12

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SECTION 16630 - CLOSED CIRCUIT TELEVISION SYSTEM GENERAL PROVISIONS

PART 1 - GENERAL:

SUMMARY:

This section details the requirements for an engineered closed circuit television system (CCTVS). The Subcontractor is responsible for all work described in this specification. The Subcontractor shall furnish and install all equipment, materials and supplies and perform all work and operations necessary to complete the work as shown on the contract drawings and as specified herein. Upon completion of installation, the Subcontractor shall operate and test the CCTVS in the presence of the Contractor's representative as specified hereafter to verify that the systems are properly installed and operates as required.

WORK DESCRIPTION:

1. The Subcontractor shall select a single CCTVS vendor for design, fabrication, and testing of a completely integrated system.
2. The Subcontractor shall be responsible for the on-site installation of the CCTVS, complete with all necessary accessories, components, cables, materials, hardware and on-site testing assistance from the CCTVS supplier, to assure a complete, operational system.
3. The specific work to be accomplished under this specification is to design a CCTVS in accordance with the performance requirements specified herein, including, fabrication, installation, and testing of the CCTVS comprising cameras, pan and tilt actuators, camera controllers, video monitors, operator controls, video tape recorders, switches, cable assemblies, equipment racks, conduit, fittings, hangers, supports, cable tray, and all necessary accessories and components to assure a complete and operable system.

RELATED SECTIONS:

Section 16000	Electrical General Provisions
Section 16109	Switches, Receptacles and Wallplates
Section 16100	Electrical Raceways
Section 16120	Cable, Wire, Connectors, and Miscellaneous Devices

REFERENCES:

UL STANDARDS AND PRODUCT DIRECTORIES

NFPA 70 National Electrical Code

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1 FIELD QUALITY CONTROL:

2
3 Quality assurance program requirements exist to ensure that all work is performed in
4 conformance with the requirements established by the drawings and this specification. The
5 contractor's representative will witness all testing as noted throughout these specifications.

6
7 SUBMITTALS:

8
9 Submittals include, but are not limited to:

10
11 Product Data: Submit product data for those products called out in this specification and the
12 Vendor Data Schedule to include manufacturer's technical data for each CCTVS component
13 and cable assembly.

14
15 Construction Component Testing: The Subcontractor shall submit a procedure to test the
16 CCTVS components operation and verify proper operation of each system component. After
17 testing, the Subcontractor shall submit a test report detailing the results of the testing.

18
19 QUALITY CONTROL:

20
21 Installer: Firms with successful installation experience on projects with closed circuit
22 television systems (CCTVS) similar to those required for this project.

23
24 Comply with NFPA 70 National Electrical Code

25
26 Manufacturers: Firms regularly engaged in manufacture of closed circuit television systems
27 and components.

28
29 PART 2 - PRODUCTS:

30
31 GENERAL:

32
33 The Subcontractor shall furnish all labor, materials, equipment and appliances required to
34 complete the installation of the complete CCTVS. All labor, materials, service, equipment,
35 and work will conform to the applicable chapters of the NFPA 70. All modifications required
36 by this code, will be made by the Subcontractor without additional charge to the contractor.

37
38 All materials, equipment, and installations shall be accessible for inspection by the contractor
39 (or his designated representative) during any phase of construction, fabrication, manufacture,
40 erection, or testing.

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1 SYSTEM DESCRIPTION:

2
3 Design Requirements: The CCTVS shall comply with the performance design requirements.
4 Refer to Subcontract drawings for location of the CCTVS components, equipment and
5 associated site utilities.

6
7 PERFORMANCE REQUIREMENTS:

8
9 CCTVS SUPPLIER QUALIFICATIONS:

10
11 The supplier of the CCTVS will be a company that (1) is primarily involved in the design,
12 manufacture, and assembly of integrated and complete video systems and (2) has
13 manufactured, assembled, and supplied such systems for at least 5 years.

14
15 CCTVS BLOCK DIAGRAM:

16
17 The riser or block diagrams will be reviewed for approval based on its functional equivalence
18 to the cable riser diagrams shown in the Subcontract drawings.

19
20 To assist in the design of the CCTVS, the length of each cable is closely estimated in this
21 specification. A 10% increase in length has been included in the estimated footage for the
22 long cables: CAB104, CAB105, CAB106, CAB107, CAB117, CAB127, CAB129, CAB130,
23 CAB131. It will be the responsibility of the Subcontractor to field confirm the actual cable
24 lengths.

25
26 SPARE PARTS:

27
28 The Subcontractor will supply the following equipment as spare parts:

- 29
30 1 video camera
31 1 Pan and Tilt Actuator
32

33 TEST PLAN:

34
35 Before shipment, the CCTVS supplier will test the complete CCTVS to verify signal quality,
36 strength, and control functions. Testing, which will be documented in the CCTVS supplier
37 test report, will include the following:

- 38
39 1. Verification of "Full Video Signal" at all video recorder and video monitor input
40 ports as being at a minimum of 400 TV lines.
41 2. Verification that the full range of pan and tilt motion of the pan and tilt actuator is
42 achieved.

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3. Verification that the full zoom range of each camera lens is achieved by the excavator control panel (VM_CP_12).
4. Verification that the manual-override for zoom, focus, and iris is achieved by the controls at the camera control units or their functional equivalent.

TEST REPORT:

The CCTVS test report will include a tabular schedule that reports the results of the testing plan.

SUBCONTRACT DRAWINGS:

The following drawings are provided as a guide and a baseline minimum criteria for the design of the CCTVS:

1. Drawing 522781 'Abbreviations, Legend and General Notes'
2. Drawing 522782 'Dig Face Cameras – Cable Riser Diagram'
3. Drawing 522783 'Glove Box Cameras – Cable Riser Diagram'
4. Drawing 522784 'Excavator Control Panel (VM_CP_12), 'Proposed Layout'
5. Drawing 522785 'Video Equipment Racks – Proposed Layout'

SHIPPING:

The video equipment racks will be shipped fully assembled with the applicable video equipment mounted securely in the racks and connected together with the inter-rack video cables in accordance with the cable riser diagrams.

DESIGN REQUIREMENTS:

The CCTV system includes all equipment necessary to be complete and operational:

1. All cable assemblies
2. Cameras
3. Pan and tilt controllers
4. Switches
5. Controllers
6. Recorders
7. Monitors
8. Equipment racks
9. Power supplies.

The CCTV cable riser and block diagram of the system, showing components and their connections, are contained in the CCTVS Subcontract drawings.

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Video Equipment Racks: Video equipment racks will be located in the WES and will be adjacent to each other (See Drawing 522786). The 0.5-m (19-in.) video equipment racks will contain all of the CCTVS equipment except for the pan and tilt actuators, cameras, two monitors (VM_MON_7 and VM_MON_5), and a control panel (VM_CP_12) at the excavator.

The CCTVS equipment for the RCS cameras will require one rack (VER1), and the video equipment for the glovebox cameras will require two racks (VER2, VER3) Proposed layouts of all the video equipment racks are included in Drawing 522785 of the Subcontract drawings.

An adequate quantity of 20 amp, 110-Vac power strips will be mounted in the video equipment racks to accommodate the requirements of all CCTVS equipment located in the rack. The power strips for the video equipment racks will include surge protection devices.

Labeling Of Equipment: Each device in the CCTVS shall be clearly labeled with the device identification, as indicated in the Subcontract drawings. Labels shall be black phenolic with minimum of 1/8 inch white lettering.

Video Cameras – Mounted On The Rcs Structure: A total of four RCS cameras with pan and tilt actuators are required. A description of the requirements for the four RCS cameras is provided below:

1. Each camera will be capable of high resolution, high sensitivity, and a zoom range of 72:1 incorporating both an 18:1 optical zoom and an additional 4:1 electronic zoom.
2. The optical zoom range will provide full resolution with a horizontal field of view range from 48 degrees to 2.7 degrees (at a minimum).
3. Each camera must provide a high-resolution (more than 460 TV lines) S-video format. It must feature remote zoom control, automatic or remote focus control, and automatic or remote iris control.
4. An onscreen display must provide for zoom position and other function settings.
5. Output connectors must be provided on the rear of the camera for attachment to a pan and tilt actuator.
6. Each camera housing must be anodized aluminum and incorporate an abrasion resistant protective window.

The specifications for the RCS cameras are listed below and based on Model RCS-3100DP distributed by R. J. Electronics, located in Salem, Oregon.

1. Voltage: 12 to -24 VDC internally regulated
2. Sensor: 0.6-cm (1/4-in.) charge-coupled device (CCD)
3. Horizontal resolution: more than 460 TV lines
4. Format: S-video standard

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5. Minimum scene illumination: 3.0 lx without integration, 0.20 lx with integration
6. Signal to noise (S/N) ratio: More than 50 dB
7. Output impedance: 75 ohms
8. Zoom: 72:1 remote controlled and 18:1 optical zoom (4.1 mm to 73.8 mm)
9. Focus: Remote or automatic control
10. Iris: Remote or automatic control
11. Shortest focus distance: 10-mm wide angle, 800-mm telephoto
12. Field of view: 48 to 2.7 degrees horizontal
13. Size: 7.6 × 7.6 × 14.6-mm (3 × 3 × 5-3/4-in.) maximum
14. Housing material: anodized aluminum
15. Window material: Thermoset ADC
16. Temperature rating: 0 to 50° C.

Pan And Tilt Actuators For RCS Cameras: A total of four Pan and Tilt actuators for the RCS cameras are required. A description of the requirements for the four Pan and Tilt Actuators is provided below:

1. The pan and tilt actuator will be equipped with low-voltage, variable-speed motors with adjustable scanning speed to match the task being performed. The speed range shall, as a minimum, include 0.30 to 4.0 rpm.
2. The scan range for the horizontal axes will be a minimum of 360 degrees and the unit will be equipped with a yoke assembly that permits the tilt range to be a full 180 degrees with no interference resulting from the connector location.
3. The housing and external components will be made of anodized aluminum for corrosion resistance and environmental protection.
4. The minimum torque rating will be 6.25 ft-lb (75 in.-lb).

The specifications for the Pan and Tilt actuators are listed below and based on Model PTE-150, distributed by R. J. Electronics, located in Salem, Oregon.

1. Voltage: 1.8 to 24 Vdc
2. Height, width, and depth: 18, 13, and 5.7-cm (7, 5.5, and 2.25-in.) maximum, respectively
3. Weight: 1.2-kg (2-3/4-lb) maximum
4. Holding torque: 8.25 ft-lb minimum
5. Pan and tilt speed: 0.30 to 4.0 rpm (1.8 to 24 degrees/second)
6. Pan range: 360 degrees
7. Tilt range: 180 degrees
8. Base mounting: Anodized aluminum plate 11-cm (4.5-in.) outside diameter with mounting holes for No. 10 screws equally spaced on 10-cm (4-in.) bolt circle.

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Video Cameras – Mounted On The Three Glove Boxes: A total of three video cameras are required. A description of the requirements for the three cameras is provided below:

1. Each camera will be capable of high resolution, high sensitivity, and a zoom range of 72:1 incorporating both an 18:1 optical zoom and an additional 4:1 electronic zoom.
2. The optical zoom range will provide full resolution with a horizontal field of view range from 48 degrees to 2.7 degrees (at a minimum).
3. Each camera must provide a high-resolution (more than 460 TV lines) S-video format. It must feature remote zoom control, automatic or remote focus control, and automatic or remote iris control.
4. An onscreen display must provide for zoom position and other function settings.
5. Output connectors must be provided on the rear of the camera for attachment to a pan and tilt actuator.
6. Each camera housing must be anodized aluminum and incorporate an abrasion resistant protective window.

The specifications for the glovebox cameras are listed below and will be based on Model RCS-3100DP, manufactured by R.J. Electronics, located in Salem, Oregon.

1. Voltage: 12 to 24 VDC internally regulated
2. Sensor: 0.6-cm (1/4-in.) CCD
3. Horizontal resolution: More than 460 TV lines
4. Format: S-video standard
5. Minimum scene illumination: 3.0 lx without integration, 0.20 lx with integration.
6. Signal to noise (S/N) ratio: More than 50 dB
7. Output impedance: 75 ohms
8. Zoom: 72:1 remote controlled and 18:1 optical zoom (4.1 mm to 73.8 mm)
9. Focus: Remote or automatic control
10. Iris: Remote or automatic control
11. Shortest focus distance: 10-mm wide angle, 800-mm telephoto
12. Field of view: 48 to 2.7 degrees horizontal
13. Size: 7.6 x 7.6 x 14.6 mm (3 x 3 x 5.75-in.) maximum
14. Housing material: anodized aluminum
15. Window material: Thermoset ADC
16. Temperature rating: 0 to 50° C.

Camera Control Unit – Manufacturing And Assembly: Each of the video cameras requires a dedicated camera control unit with the exception of the three glove box cameras, which will require a single camera control unit. The specific requirements applying to each of these camera control units is given below.

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1. The camera control units shall be designed for mounting in a standard 48-cm (19-in.) equipment rack.
2. The camera control units shall provide 24-Volt D.C. power for the cameras as well as for the pan and tilt actuators, in the case of the RCS cameras.
3. The means to override the automatic focus, and iris and provide local zoom for each of the cameras shall be provided. In the case of the glove box camera control unit, this capability will consist of a single set of controls with a rotary camera select switch to provide the means to select the glove box camera that requires manual adjustment of focus, iris, and zoom.

Cable Port Assignments For The Four Rcs Camera Control Units: The cable port assignments listed below will serve to define the multi-function capability of the camera control units as well as identify the cable number and estimated length of each cable: (see Drawing 522782)

Port 1: Port 1 provides a cable connection to the camera and pan and tilt actuator. The purpose of this cable connection is to provide camera power and pan and tilt actuator control functions and to receive video signals from the cameras. The Port 1 connections and the associated cable lengths for each RCS camera control unit are listed below:

1. **Camera Control Unit 1 (VM_ZC_11):** CAB107 (video/power/control) to Camera 1 (VM_TVC_1), 50 m (165 ft)
2. **Camera Control Unit 2 (VM_ZC_21):** CAB106 (video/power/control) to Camera 2 (VM_TVC_2), 56 m (185 ft)
3. **Camera Control Unit 3 (VM_ZC_31):** CAB105 (video/power/control) to Camera 3 (VM_TVC_3), 72 m (235 ft)
4. **Camera Control Unit 4 (VM_ZC_41):** CAB104 (video/power/control) to camera 4 (VM_TVC_4), 59 m (195 ft).

Port 2: Port 2 feeds the camera signal listed below to the monitor input select switch (VM_SEL_9) for each of the four camera control units. The Port 2 connections and the associated cable lengths for each RCS camera control unit are listed below:

1. **Camera Control Unit 1 (VM_ZC_11):** CAB111 (S-VHS), 1.8 m (6 ft) or less
2. **Camera Control Unit 2 (VM_ZC_21):** CAB110 (S-VHS), 1.8 m (6 ft) or less
3. **Camera Control Unit 3 (VM_ZC_31):** CAB 109 (S-VHS), 1.8 m (6 ft) or less
4. **Camera Control Unit 4 (VM_ZC_41):** CAB108 (S-VHS), 1.8 m (6 ft) or less.

Port 3: Port 3 feeds the camera signal listed below to the remote function control matrix, (VM_SEL_16) for each camera control unit. The port 3 connections and the associated cable lengths for each RCS camera control unit are listed below:

1. **Camera Control Unit 1 (VM_ZC_11):** CAB124 (S-VHS), 1.8 m (6 ft) or less.

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2. **Camera Control Unit 2 (VM_ZC_21):** CAB122 (S-VHS), 1.8 m (6 ft) or less
3. **Camera Control Unit 3 (VM_ZC_31):** CAB120 (S-VHS), 1.8 m (6 ft) or less
4. **Camera Control Unit 4 (VM_ZC_41):** CAB118 (S-VHS), 1.8 m (6 ft) or less.

Port 4: Port 4 provides cable connections to the remote function control matrix, (VM_SEL_16). The purpose of these cable connections, is to provide camera pan, tilt, and zoom and manual focus and iris commands to the camera selected by the Excavator Control Panel (VM_CP_12) as relayed through the remote function control matrix (VM_SEL_16) for each camera control unit.

The port 4 connections and the associated cable lengths for each RCS camera control unit are listed below:

1. **Camera Control Unit 1 (VM_ZC_11):** CAB125 (video/control interface), 1.8 m (6 ft) or less.
2. **Camera Control Unit 2 (VM_ZC_21):** CAB123 (video/control interface), 1.8 m (6 ft) or less
3. **Camera Control Unit 3 (VM_ZC_31):** CAB121 (video/control interface), 1.8 m (6 ft) or less
4. **Camera Control Unit 4 (VM_ZC_41):** CAB119 (video/control interface), 1.8 m (6 ft) or less.

Cable Port Assignments For The Four Glove Box Cameras (Drawing 522783): The CCTVS will have three glove box cameras. These cameras will not require pan and tilt control, but will require remote adjustment of the zoom and a manual override of the automatic focus and iris control. The three glove box cameras will be interfaced with a single camera control unit (VM_ZC_5). The cable port assignments listed below will serve to define the multi-function capability of the camera control unit as well as identify the cable number and estimated length of each cable:

Port 1: Port 1 will be designated for the cable (CAB129, video, power, and control) connected to the camera at Glovebox 3 (VM_TVC_7). The required length of CAB129 is 73 m (260 ft).

Port 2: Port 2 will be designated for the cable (CAB130, video, power, and control) connected to the camera at Glovebox 2 (VM_TVC_6). The required length of CAB130 is 58 m (205 ft).

Port 3: Port 3 will be designated for the cable (CAB131, video, power, and control) connected to the camera at Glovebox 1 (VM_TVC_5). The required length of CAB131 is 49 m (175 ft).

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1 Port 4: Port 4 will be designated for the cable (CAB132, S-VHS) connected to the video
2 input (Port 1) of videotape recorder, (VM_VTR_51). The required length of CAB33 is 1.8 m
3 (6 ft) or less.

4
5 Port 5: Port 5 will be designated for the cable (CAB133, S-VHS) connected to the video
6 input (Port 1) of videotape recorder (VM_VTR_62). The required length of CAB 34 is 1.8 m
7 (6 ft) or less.

8
9 Port 6: Port 6 will be designated for the cable (CAB134, S-VHS) connected to the video
10 input (Port 1) of videotape recorder (VM_VTR_73). The required length of CAB35 is 1.8 m
11 (6 ft) or less.

12
13 Remote Function Control Matrix (Vm Sel 16): One remote function control matrix
14 (VM_SEL_16) will relay, coordinate, and control all video and control signals that originate
15 at the excavator control panel. The primary function of the remote function control matrix is
16 to provide switching to route the pan, tilt, and zoom control functions from the excavator
17 control panel to the appropriate camera control unit and camera and to switch the video
18 signals feeding from each of four camera control units to the primary video recorder. The
19 specific requirements given below apply to the remote function control matrix.

20
21 Mounting: The Remote Function Control Matrix will be designed for mounting in a standard
22 48-cm (19-in.) equipment rack.

23
24 Cable Port Assignments For Remote Function Control Matrix: The specified uses of all cable
25 ports and the required cable lengths for the Remote Function Control Matrix are listed below:

26
27 Port 1: Port 1 is for the composite video cable (CAB126) output to the primary videotape
28 recorder (VM_VTR_13), at Port 2. The length of this cable will be 1.8 m (6 ft) or less.

29
30 Port 2: Port 2 is for the composite video cable (CAB116) output to the monitor input select
31 switch (VM_SEL_9) at Port 5. The length of this cable will be 1.8 m (6 ft) or less.

32
33 Port 3: Port 3 is for the composite video cable (CAB117), output to the monitor designated as
34 VM_MON_5 at Port 1. The length of this cable will be 85 m (290 ft). If required,
35 amplification will be provided to compensate for cable losses to ensure a full video signal at
36 the monitor.

37
38 Port 4: Port 4 is for the S-VHS cable (CAB118) input from the camera control unit
39 (VM_ZC_41) at Port 3. The length of this cable will be 1.8 m (6 ft) or less.

40
41 Port 5: Port 5 is for the S-VHS cable (CAB120) input from the camera control unit
42 (VM_ZC_31) at Port 3. The length of this cable will be 1.8 m (6 ft) or less.

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1 Port 6: Port 6 is for the S-VHS cable (CAB122) input from the camera control unit
2 (VM_ZC_21) at Port 3. The length of this cable will be 1.8 m (6 ft) or less.

3
4 Port 7: Port 7 is for the S-VHS cable (CAB124) input from the camera control unit
5 (VM_ZC_11) at Port 3. The length of this cable will be 1.8 m (6 ft) or less.

6
7 Port 8: Port 8 is for the remote camera control interface cable (CAB119) connecting to the
8 camera control unit (VM_ZC_41) at Port 4. The length of this cable will be 1.8 m (6 ft) or
9 less.

10
11 Port 9: Port 9 is for the remote camera control interface cable (CAB121), connecting to
12 camera control unit (VM_ZC_31) at Port 4. The length of this cable will be 1.8 m (6 ft) or
13 less.

14
15 Port 10: Port 10 is for the remote camera control interface cable (CAB123) connecting to the
16 camera control unit (VM_ZC_21) at Port 4. The length of this cable will be 1.8 m (6 ft) or
17 less.

18
19 Port 11: Port 11 is for the remote camera control interface cable (CAB125) connecting to the
20 camera control unit (VM_ZC_11) at Port 4. The length of this cable will be 1.8 m (6 ft) or
21 less.

22
23 Port 12: Port 12 is for the remote camera control interface cable (CAB127) connecting to the
24 excavator control panel (VM_CP_12) at Port 1. The length of this cable will be 52 m (260 ft).

25
26 Monitor Input Select Switch (VM_SEL_9): One Monitor Input Select Switch (VM_SEL_9)
27 will be used in the CCTVS. The primary function of the switch is to provide switching of a
28 minimum of seven separate video input signals that are available to be viewed on monitor
29 (VM_MON_6). The underlying requirement for the switch is to provide a convenient means
30 for maintenance and zoom adjustment of the RCS cameras, as well as allowing review of
31 videocassette tapes simultaneously with ongoing recording of the selected RCS camera
32 signals.

33
34 Cable Port Assignments For The Monitor Input Select Switch: The specified uses of all cable
35 ports and the estimated cable lengths for the Monitor Input Select Switch are listed below:

36
37 Port 1: Port 1 is for the video input (CAB108) from Port 2 of camera control unit
38 (VM_ZC_41). The length of this cable will be 1.8 m (6 ft) or less.

39
40 Port 2: Port 2 is for the video input (CAB109) from Port 2 of camera control unit
41 (VM_ZC_31). The length of this cable will be 1.8 m (6 ft) or less.

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1 Port 3: Port 3 is for the video input (CAB110) from Port 2 of camera control unit
2 (VM_ZC_21). The length of this cable will be 1.8 m (6 ft) or less.

3
4 Port 4: Port 4 is for the video input (CAB111) from Port 2 of camera control unit
5 (VM_ZC_11). The length of this cable will be 1.8 m (6 ft) or less.

6
7 Port 5: Port 5 is for the video input (CAB116) from Port 2 of the remote function control
8 matrix (VM_SEL_16). The length of this cable will be 1.8 m (6 ft) or less.

9
10 Port 6: Port 6 is for the video input (CAB114) from Port 1 (video out) of the primary
11 videotape recorder (VM_VTR_13). The length of this cable will be 1.8 m (6 ft) or less.

12
13 Port 7: Port 7 is for the video input (CAB113) from Port 1 (video out) of the backup
14 videotape recorder (VM_VTR_14). The length of this cable will be 1.8 m (6 ft) or less.

15
16 Port 8: Port 8 is for the video output (CAB112) to Port 1 (video in) of video monitor
17 (VM_MON_6). The length of this cable will be 1.8 m (6 ft) or less.

18
19 Select switches: The select switches will be mounted in the front face of the monitor input
20 select switch and be clearly marked with numerals matching the video input ports.

21
22 All ports on the controller will be labeled in accordance with the port numbers defined above.

23
24 Video Tape Recorders: A total of six videotape recorders are required: two for the RCS
25 camera system and four for the glovebox camera system. All of the recorders will be identical
26 and will be capable of recording the video signal at a minimum of 400 TV lines. The
27 videotape recorders will be securely mounted in the 48-cm (19-in.) equipment racks with the
28 power cable plugged into a power strip and ready to operate. Configurable date and time
29 generating hardware shall be included at the input of each recorder to provide on-screen
30 label, date and time data. This equipment shall be Kalatel, Model KTS-253 or approved
31 equal.

32
33 The recorders will be JVC, Model HR-S4800U, or an approved equal. This model of recorder
34 comes standard with the following input/output connectors:

- 35
36 1. RCA (CO-AX) requiring BNC co-axial connectors—two inputs and one output
37 2. S-Video (Twin CO-AX) requiring four-pin mini-DIN cable connectors: one input and
38 one output.

39
40 The input and output connectors for each videotape recorder will be labeled to conform to the
41 following designations:

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Port Designations For The RCS Camera Recorders:

Port 1: Video output: RCA (CO-AX) [VM_VTR_13: CAB114, length – 1.8 m (6 ft) or less; VM_VTR_14: CAB113, length – 1.8 m (6 ft) or less]

Port 2: S-Video input: (Twin CO-AX) [VM_VTR_13: CAB126, length – 1.8 m (6 ft) or less; VM_VTR_14: CAB115, length – 1.8 m (6 ft) or less]

Port Designations For The Glove Box Camera Recorders:

Port 1: S-Video input: (Twin CO-AX) [VM_VTR_51: CAB132, length – 1.8 m (6 ft) or less; VM_VTR_62: CAB133, length – 1.8 m (6 ft) or less; VM_VTR_73: CAB134, length 1.8 m (6 ft) or less]

Port 2: S-Video output: (Twin CO-AX) (The required cable lengths for cables: CAB135, CAB136, and CAB137 will be 1.8 m (6 ft) or less).

Excavator Control Panel (Vm Cp-12): The excavator control panel will be a separately mounted panel (apart from the 48-cm [19-in.] equipment racks) and will provide operator interface with the RCS camera system. The requirements for this panel are given in the subsections below.

Dimensions: In accordance with the proposed design in the Subcontract drawings, the dimensions of the panel will be 10 cm high x 36 cm wide (4 in. high x 14 in. wide).

Panel finish: The panel will be painted 'Stone Gray' or 'Black' and manufactured from No. 10 gage aluminum.

Mounting: The proposed design in these specifications specifies that this panel be designed and fabricated by the CCTVS supplier for Subcontractor installation in the 'Feature Panel' space provided in the flat panel display enclosure as designed by Strongarm Designs Inc. (Mr. Bill Hankel, 935 F Horsham Road, Horsham, PA 19044, 215-443-3400, fax: 215-443-3002, www.strongarm.com) Reference Strongarm quotation # SAQ-041602-02 and Drawing 522787. The Subcontractor shall be responsible for providing the Strongarm Designs equipment as specified herein or approved equal.

Control Functions: The excavator control panel will provide the primary means of selecting one of the four RCS cameras and optimizing its video image (in terms of pan, tilt, zoom, iris, and focus) on the excavator video monitor (VM_MON_7). The selection of the camera at the excavator control panel also will direct the remote function control matrix (VM_SEL_16) to route the video signal from the selected camera to the primary videotape recorder (VM_VTR_13) and the video monitor (VM_MON_5) at the support trailer.

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1 **Excavator Control Panel Cable Port Assignments:**

2
3 **Port 1:** Port 1 is for CAB127 (video/control) to the remote function control matrix at Port 12.

4
5 **Port 2:** Port 2 is for CAB6 (S-VHS) to video monitor (VM_MON_7).

6
7 **Excavator Control Panel – Control Operators:** The various types of control provided by the
8 control panel are listed below:

9
10 **Camera select:** The camera select will consist of four buttons labeled 1 through 4. pushing
11 one of the four buttons will select the camera associated with that button, deselecting the
12 other three cameras and direct the following control functions to the selected camera.

13
14 **Pan and Tilt:** Pan and tilt control will be initiated by means of a joy-stick type of operator
15 where up and down movement of the operator directs the tilt actuator to move up and down,
16 respectively. Left and right movement of the operator will direct the pan actuator to rotate left
17 and right, respectively.

18
19 **Zoom:** Zoom control will be initiated by means of a rocker switch where upward movement
20 of the switch causes the camera lens to zoom “in” and downward movement of the switch
21 causes the camera lens to zoom “out.”

22
23 **Focus:** Though the cameras have been specified to include automatic focus control, manual
24 override controls will be provided to manually adjust the focus. These controls will consist of
25 a momentary “Manual Select” pushbutton and a rocker switch that permits manual focus of
26 the camera lens. Upward movement of the rocker switch causes near adjustment of the focus
27 and downward movement of the rocker switch causes far adjustment of the focus.

28
29 **Auto focus indicator:** The auto focus indicator consists of a pilot light indicator that
30 illuminates when the camera is in “auto focus” mode.

31
32 **Iris:** Although the cameras have been specified to include automatic iris control, manual
33 override controls will be provided to manually adjust the iris. These controls will consist of a
34 momentary “Manual Select” pushbutton and a rocker switch that permits manual iris
35 adjustment of the camera lens where upward movement of the rocker switch causes “Open”
36 adjustment of the iris and downward movement of the rocker switch causes “Close”
37 adjustment of the iris.

38
39 **Video Monitors:** A total of six video monitors are required for the CCTVS. Four of the
40 monitors will be required to be mounted in 48-cm (19-in.) equipment racks. The video
41 monitor that will be located in the support trailer (VM_MON_5) will be sitting on a desk or
42 table. The video monitor at the excavator (VM_MON_7) will be mounted in an enclosure on
43 an adjustable arm so that the monitor can be maneuvered inside the excavator cab for the

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convenience of the excavator operator. (Drawing 522787) The Subcontract drawings indicate which equipment rack to install the monitors. As indicated on the drawings, the layout of the video equipment in the equipment racks is proposed for the purpose of indicating as clearly as possible an arrangement that will meet the requirements of process operations. With the exception of the video monitor (VM-MON_7), located at the excavator (specified as Drawing 522787), the video monitors will meet the following requirements:

1. Resolution: 500 TV lines
2. Inputs: one Y/C IN (four-pin mini-DIN cable connector) and one video IN (a BNC co-axial cable connector).
3. Outputs: one loop-through Y/C OUT (four-pin mini-DIN cable connector) with automatic 75-ohm termination and one loop-through video OUT (BNC co-axial connector) with automatic 75-ohm termination.
4. Power consumption: Approximately 100 W
5. Screen size: 20-in. cathode ray tube (19-in. diagonally)
6. Voltage requirement: 100 to 240 Vac, 50/60 hz.
7. Sony Trinitron, Model SSM20N5U, or an approved equal.

CCTVS Cables:

General requirements: Each video cable will be furnished fully assembled with the cable and cable connectors on both ends. Each cable will be labeled at both ends of the cable with the cable number and the device number and port number of the device into which it will be plugged.

Labeling will be neat and legible in machine printed characters on Brady heat-shrinkable labels, or approved equal.

Individual cable lengths have been closely estimated in this performance specification with an increase of 10% above the 'close estimate'. The Subcontractor will be responsible to verify the actual cable lengths.

CONDITION OF PRODUCTS:

The Subcontractor will provide new products, free of defects and harmful deterioration, at the time of installation. The Subcontractor will provide each product complete with trim, accessories, finish, guards, safety devices, and similar components specified or recognized as integral parts of the product, or components required by governing regulations.

Unless otherwise indicated by the shop drawings or specifications, or approved in writing, the materials and equipment furnished under these specifications will be the standard products of those manufacturers who are regularly engaged in the production of such equipment, and shall be the manufacturer's standard design.

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1 **DAMAGED MATERIALS:**

2
3 All materials and equipment received by the Subcontractor in a damaged condition shall be
4 repaired or replaced by the Subcontractor, as directed by the contractor. Materials and
5 equipment damaged by the Subcontractor will be repaired or replaced by the Subcontractor at
6 Subcontractor's expense.

7
8 **PART 3 - EXECUTION:**

9
10 The steps required for execution of the CCTVS are given in the subsections below:

11
12 **INSTALLATION:**

13
14 The CCTVS will be installed onsite by the Subcontractor with the assistance of the video
15 system supplier's field representative. Installation will consist of the following steps:

- 16
17 1. Installing four color video cameras with pan & tilt actuators on the RCS walls and
18 ceiling: VM_TVC_1, 2, 3, 4; Three color video cameras without pan & tilt actuators
19 on the three glove boxes: VM_TVC_5, 6, 7; One remote video monitor: VM_MON_7
20 in the support trailer (WMF-646); One combined control panel {(Excavator Control
21 Panel – VM_CP_12) and video monitor (VM_MON_7)} at the excavator.
22 2. Installation of three video equipment racks that contain four video monitors –
23 VM_MON_6, 51, 62, 73; five camera control units – VM_ZC_11, 21, 31, 41, 5; Six
24 video tape recorders: VM_VTR_13, 14, 51, 62, 73, 17; one Remote Function Control
25 Matrix - VM_SEL_16; and one Monitor Input Select switch – VM_SEL_9. These
26 racks will require secure attachment to the WES floor in the designated location on
27 the drawings.
28 3. Installation of required cable tray and installation of the nine video cables connecting
29 the remote cameras, PTZ actuators, video monitors and excavation control panel to
30 the equipment in the video equipment racks.

31
32 **TRAINING:**

33
34 The Subcontractor will arrange with the CCTVS supplier to provide onsite training and
35 system operation manuals.

36
37 **MAINTENANCE:**

38
39 The Subcontractor will obtain from the CCTVS supplier, documentation that provides the
40 manufacturer's recommended maintenance procedures for each piece of equipment.

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1 REPAIR OF DAMAGES:

2
3 Construction materials and equipment, threads (machined or painted), and other exposed
4 finished surfaces must be protected from damage at all times during shipping, handling,
5 construction, and installation. Materials and equipment repaired or replaced by the
6 Subcontractor is subject to acceptance by the contractor or the contractor's representative.

7
8 COORDINATION OF CLOSED CIRCUIT TELEVISION SYSTEM WORK:

9
10 General requirements: Materials and equipment will be erected or installed only by qualified
11 personnel who are regularly engaged in the trades required to complete the work. The
12 subcontract drawings show the general arrangement and space allocation of the equipment
13 specified. The Subcontractor is responsible for verifying changes in conditions or
14 rearrangements necessary because of substitutions for specified materials or equipment.
15 When rearrangements are necessary, the Subcontractor must, before construction or
16 installation, prepare and submit drawings of the proposed rearrangement for approval. The
17 drawings and changes will be made at no cost to the contractor.

18
19 Coordination of Work: The Subcontractor will cooperate in coordinating his work with work
20 being done by others. The Subcontractor must notify the contractor at least 1 week prior to
21 the date on which the Subcontractor proposes to proceed with the work.

22
23 QUALITY OF WORK:

24
25 All work must be done in a skillful and professional manner. The Subcontractor must do all
26 structural cutting, fitting, patching, repairing, and associated work necessary for installation
27 of equipment, wiring and electrical conduits, cable trays, and so on. No major cuts or holes
28 not shown on the drawings will be made without prior approval of the project manager. After
29 the equipment, cable tray, and conduit are installed, all exposed holes, cracks, and other
30 defects must be neatly patched, and the patched areas must match the adjoining materials and
31 finish.

32
33 The Subcontractor must arrange work in a neat, well-organized manner with conduit, cable
34 tray, and similar services running parallel with the primary lines of the building construction,
35 and with a minimum of 2 m (7 ft) overhead clearance, where possible.

36
37 The Subcontractor must ensure that the equipment is connected in accordance with
38 manufacturer's recommendations using the provided mounting holes, brackets, and hardware.

39
40 RED-LINE REQUIREMENTS:

41
42 The Subcontractor will maintain a set of red-line drawings for the entire project that must be
43 updated on a daily basis. The update must include wiring changes and major changes (greater

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1 than 0.6 m [2 ft] in location or 15 cm [6 in.] in size) in equipment locations, sizes, and
2 elevations.

3
4 The above update is subject to monitoring on a daily basis by the contractor's representative.

5
6 The Subcontractor may use the existing project drawings to perform the update. Upon
7 completion of the project, the Subcontractor must submit the as-built red-line drawings as
8 vendor data for approval.

9
10 QUALITY CONTROL TESTING:

11
12 Subcontractor supplied testing: The Subcontractor shall have the responsibility for the testing
13 of the CCTVS. This test will be performed with the assistance of the CCTVS supplier and in
14 the presence of the contractor's representative. The tests to be performed are as given in the
15 'test plan' included in these specifications.

16
17 REFERENCES:

18
19 NFPA 70, 2002, "National Electrical Code," National Fire Protection Association.

20
21 END OF SECTION 16630